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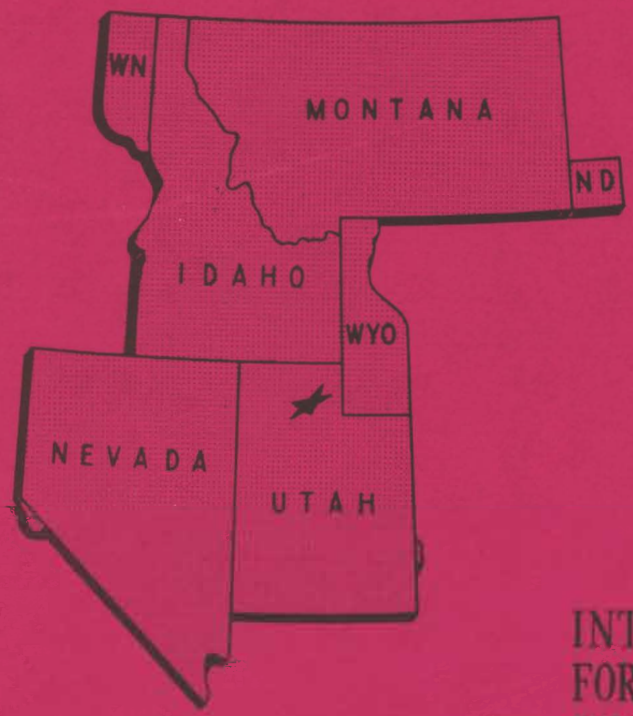
FIRE WEATHER And FIRE DANGER STATION HANDBOOK

by

Charles E. Hardy · Charles E. Syverson · John H. Dieterich



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EXPERIMENT STATION
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FIRE-WEATHER

and

FIRE-DANGER STATION

HANDBOOK

by

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April 1955

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Figure 1.

A typical fire-danger station.

I. INTRODUCTION

This is a handbook about weather stations and instruments. It is designed as a general guide for fire-control personnel who observe and record weather, who locate, operate, and maintain weather stations, and who use weather information. The handbook is intended to cover general operation of fire-danger stations maintained by the various forest protection agencies as well as fire-weather stations maintained in cooperation with the U. S. Weather Bureau.

Uniformity of judgment is the primary purpose of fire-danger rating. Adjectives are of little value--"easy," "bad," "explosive" might all be uttered by different men evaluating the same area at the same time. But, if a numerical value is assigned to the danger of a day having certain weather and fuel characteristics, that number will represent a specific meaning regardless of who says it or who hears it.

To increase the accuracy of judgment, a network of fire-danger and fire-weather stations has been developed throughout forested areas. Those forests that have greater occurrence of fires and more dangerous fuels have more stations than forests with lower occurrence and lighter fuels.

On many forests and parks there is a fire-danger station at every ranger station. In addition, each ranger district has one or more stations at lookouts. There are a few instances where two ranger districts utilize fire-danger ratings from the same lookout. Areas with low over-all fire danger may operate a much lesser number of fire-danger or fire-weather stations.

The combination of high and low stations on a district (paired stations) gives an over-all picture of conditions both on the valley floor and on the higher ridgetops. The effect of weather at intervening areas may be predicted through conversion tables.

The normal period of operation for a fire-danger station depends upon elevation, latitude, and fire characteristics in the area. In the Intermountain West the period of operation for most stations is from June or early July to about Labor Day. However, provisions are made in advance to measure fire weather continuously from early spring until late fall in the event critical conditions materialize. Fire-danger stations should always be operated when slash burning operations are contemplated. Selected ranger stations have been chosen where fire-danger stations will operate from May 1 through October 31 of each year. Use of these records over a period of many years has been of great value in fire research and fire-control administration.

The fire protection agencies and the Weather Bureau cooperate closely in the training, inspection, and maintenance phases of fire-danger rating. Information gathered is used by fire-control men in determining daily burning index, and in interpreting trend in terms of increasing or decreasing severity of the fire season. The fire-weather forecaster uses the information to give the fire-control men better daily and special forecasts.

II. THE FIRE-DANGER STATION

FIRE-DANGER STATIONS AND FIRE-WEATHER STATIONS

At a fire-danger station sufficient weather data are collected for the computation of burning index. Burning index is a numerical description of the ease with which a fire will start and spread. Fuel moisture, relative humidity, wind, precipitation, and lightning are recorded. It is operated primarily for the benefit of the protection agency.

At a fire-weather station all the fire-danger station services are performed but in addition observations are made for the U. S. Weather Bureau, such as hygrothermograph records, maximum and minimum temperatures, cloud types, and exact periods of precipitation and of thunderstorm activity. Most of the instruments and equipment at a fire-weather station are owned by the U. S. Weather Bureau. Chapter III discusses in detail operating and recording procedures for both types of stations.

STATION LOCATION

Burning index meters are constructed from data taken at open, unshaded locations. Any deviation from the standards set forth below are apt to result in inaccurate ratings.

Locate station in an area free of trees, brush, and buildings; the opening should be large enough, particularly in the direction toward the prevailing wind, for the airflow to pass over fuel sticks and psychrometer.

Locate on the windward side of lawns, irrigated pastures, gardens, etc. Avoid swampy land. (A lake or river seems to affect readings less than a swamp.)

Locate on the windward side of a dusty road or parking area.

Select a valley bottom or a ridgetop, or a slightly south or southwest exposure.

Avoid narrow canyons. Sunlight must reach the fuel sticks early in the morning, and remain on them until as near official sundown as possible.

Place station near the observer's duty post so that he will not be gone more than 15 minutes.

A 10-percent slope is recommended as maximum on which to locate a station.

The anemometer need not be at the same spot as the other instruments; it is not always feasible to get full sunlight exposure and unrestricted access to prevailing winds at the same locations.

Place the anemometer 20 feet above the ground at an unobstructed site. If this is not possible, use in a general way the rules of thumb as depicted in figure 2.

Set the anemometer between 5 and 10 feet above the rooftop if it must be placed on a building.

Try not to place the anemometer on top of a sharp mountain peak or ridge, or near other distinct changes in topography where wind velocities are unduly affected.

On a mountaintop with trees close by on the windward side, the anemometer must be at least as high as the treetops, and preferably several feet higher to allow for the upward deflection of the wind. Figure 3 shows the reasoning for this.

ARRANGEMENT OF INSTRUMENTS

The arrangement in figure 4 affords a free flow of air and full exposure of sunlight to all instruments throughout the day. The minimum setup can be used when there is no need for an instrument shelter. However, at all permanent fire-danger stations an instrument shelter housing a fan psychrometer is highly desirable. A fan psychrometer, maximum-minimum thermometer, or hygrothermograph will require an instrument shelter, and thus a standard setup.

PHYSICAL PLANT

Fence

A fence may serve two purposes: Keep people and animals out and give the fire-danger station a better appearance. Both reasons are rather important. However, at a trail chance lookout where visitors are few and no trouble is had with porcupines, deer, etc., there is no real need to fence a fire-danger station. If a picket fence is constructed, do not place the pickets so close together as to shade the fuel sticks or to restrict free movement of ground air.

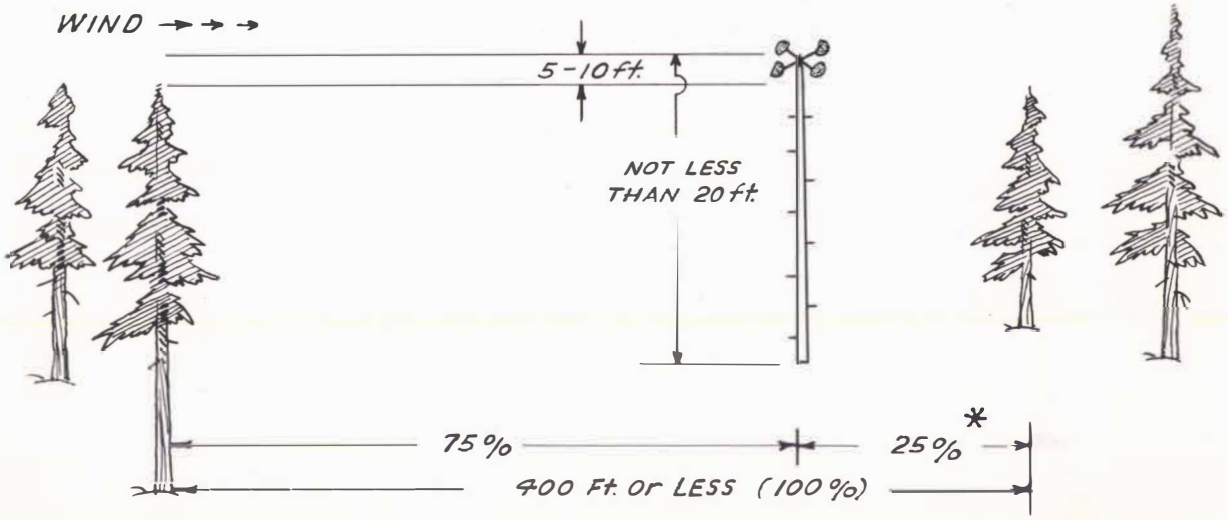
Anemometer Pole

Place the anemometer 20 feet above the ground or at an equivalent height as in figures 2 and 3.

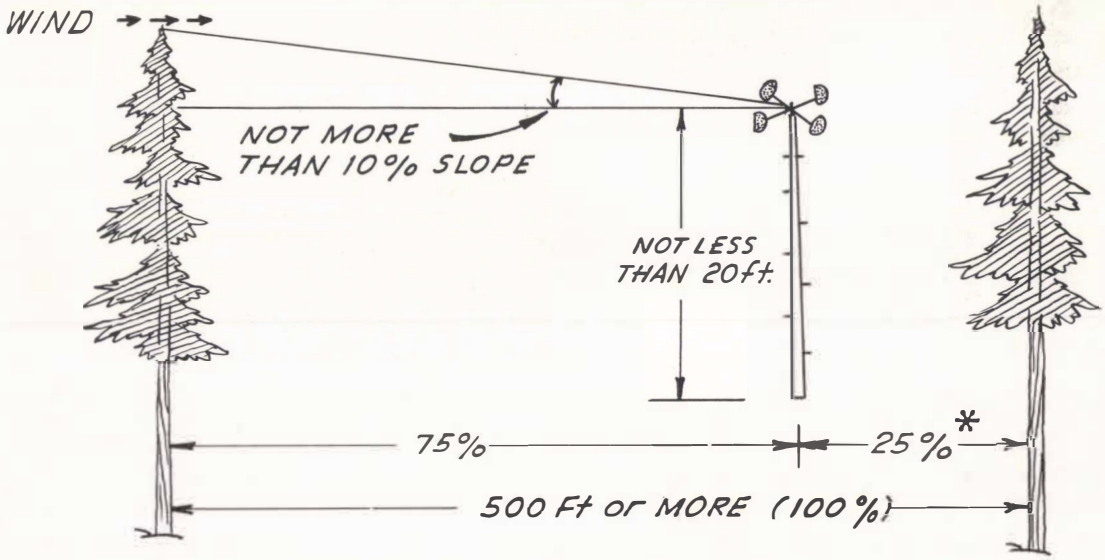
The pole must be of sound material, 6-inch top.

ANEMOMETER HEIGHT AVERAGE LOCATION

PLACEMENT OF ANEMOMETER IN SMALL CLEARING



PLACEMENT OF ANEMOMETER IN LARGE CLEARING



* If placed too close to obstructions on the lee side, eddy currents will cause unreliable readings.

Figure 2. Height of anemometer in small and large clearings.

ANEMOMETER HEIGHT
MOUNTAINTOP

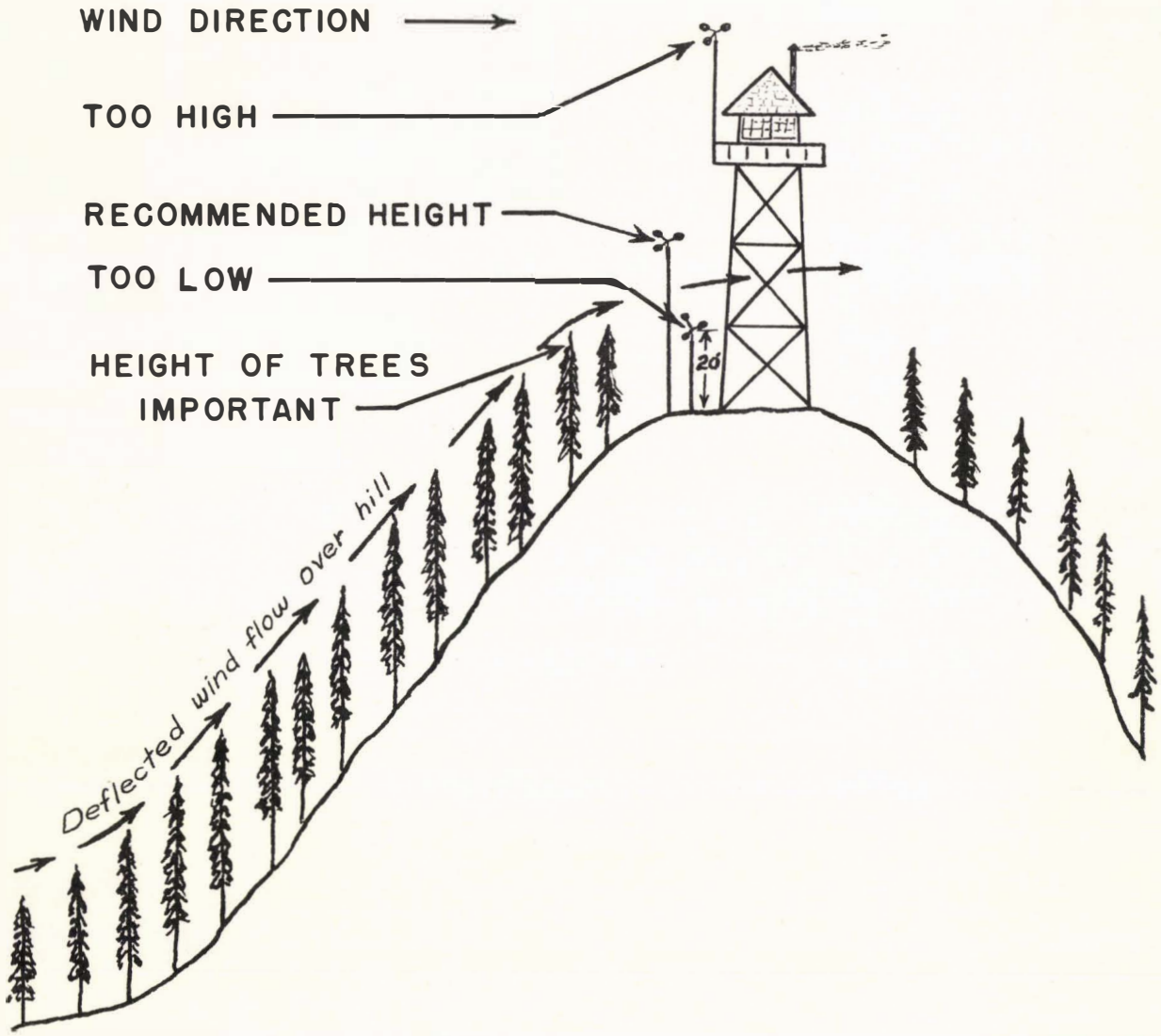
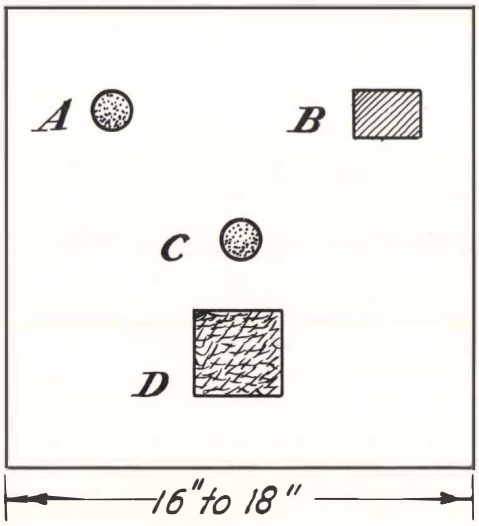


Figure 3. Height of anemometer at a mountaintop station. Use judgment in allowing for nearby timber when installing anemometer.

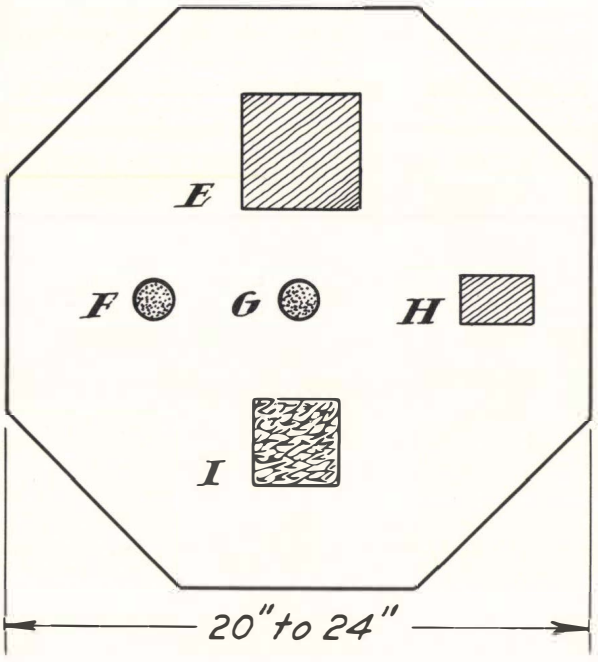
FIRE DANGER STATION ARRANGEMENT

MINIMUM GROUND PLAN



A Anemometer pole
B Scale house
C Rain gage
D Duff bed & screen

STANDARD GROUND PLAN



E Instrument shelter
F Rain gage
G Anemometer pole
H Scale house
I Duff bed & screen

Figure 4. Ground plans for fire-danger station: Upper, minimum setup; Lower, standard setup.

The pole must be firmly embedded in the ground.

Put in pole steps at 20-inch intervals, so the anemometer can be installed and taken down in a safe manner, and maintained regularly.

Mount the anemometer solidly and vertically. Two methods are shown in figure 5.

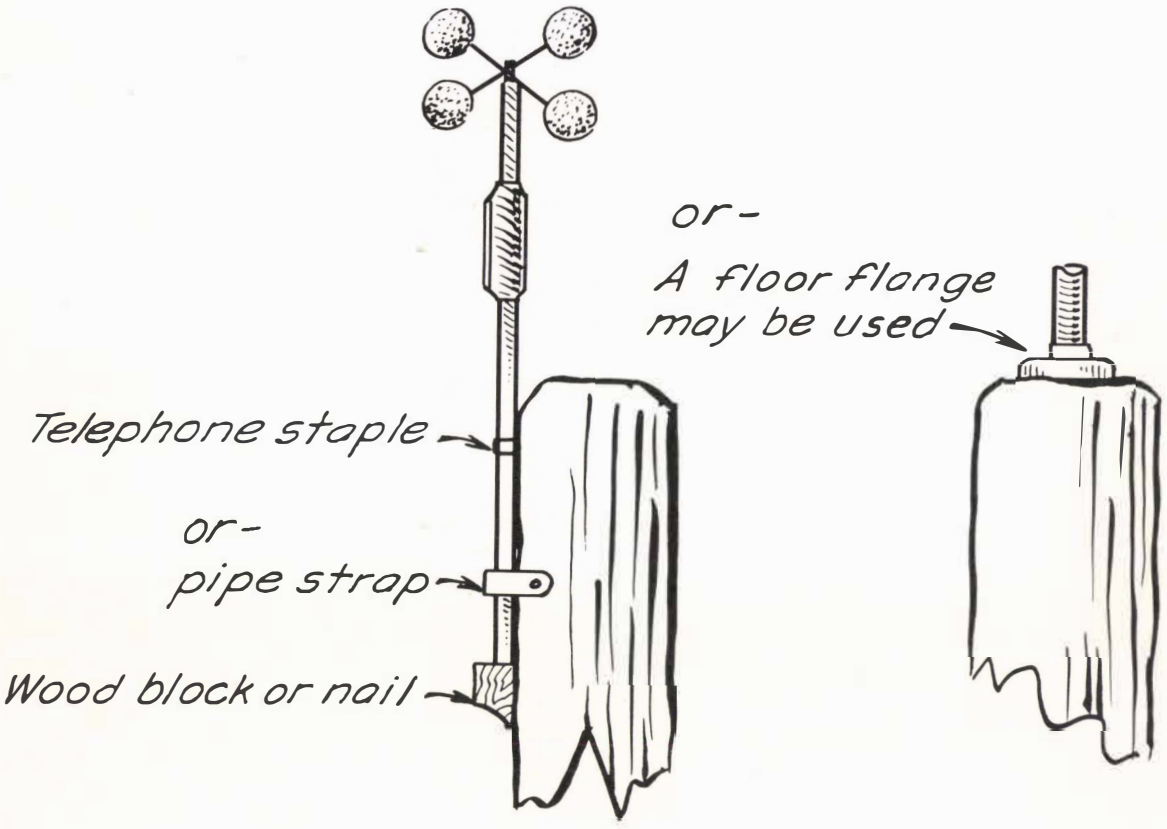


Figure 5. Two ways to mount an anemometer on a pole.

Lightning Protection

Good safety practices dictate installing adequate lightning protection on the anemometer pole, and on the wires leading onto the office or tower. Figure 6 shows suggested methods of installation.

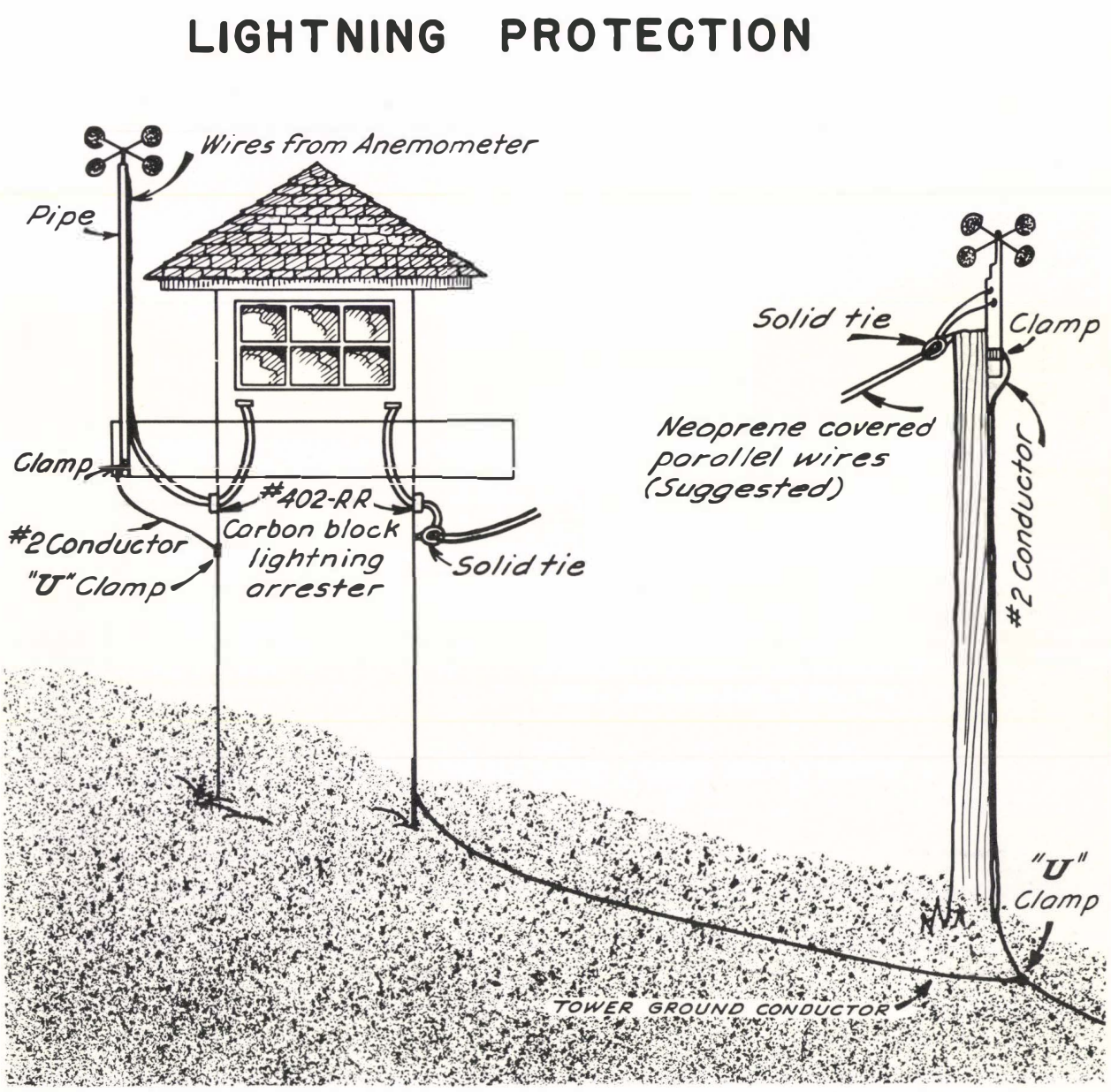


Figure 6. Suggested methods for obtaining adequate lightning protection.

If the anemometer is mounted on the catwalk of tower:--Clamp a piece of #2 copper conductor onto the pole (if pipe) or anemometer itself (if pole is wood).

Run the conductor underneath the catwalk and clamp it to the regular lightning protection system.

Run the anemometer-to-buzzer wires under the catwalk. On the tower leg install a carbon block lightning arrester (#402-RR is suggested) through which the wires should go before entering the cabin.

If the anemometer is mounted on a pole away from the structure:-- Clamp a piece of #2 copper conductor onto the anemometer or its pipe support.

Run conductor down to the ground and slamp onto the tower's ground wire.

If no tower ground wire is available, drive in a separate ground rod for the pole.

Run anemometer-to-buzzer wires from a solid tie on the pole to a solid tie on tower leg. Then wire through a #402-RR (or equivalent) arrester before the wires are led into the building.

Instrument Shelter

There are 2 types of instrument shelters in general use: The Region 1 type and the cotton region type (figure 7). The Weather Bureau installs cotton region shelters at most of its fire-weather and/or climatological stations; very few are owned by the U. S. Forest Service. The Region 1 type can be made up easily wherever carpentry tools are available.

A good instrument shelter is needed to house a fan psychrometer, maximum-minimum thermometers, or a hygrothermograph. If only a sling psychrometer is used, it can be kept in the scale house.

Keep the instrument shelter painted glossy white to reflect heat.

Mount shelter solidly. Be sure that shelter floor is level.

Mount shelter with opening to the north to protect the instruments from the sun and prevailing wind.

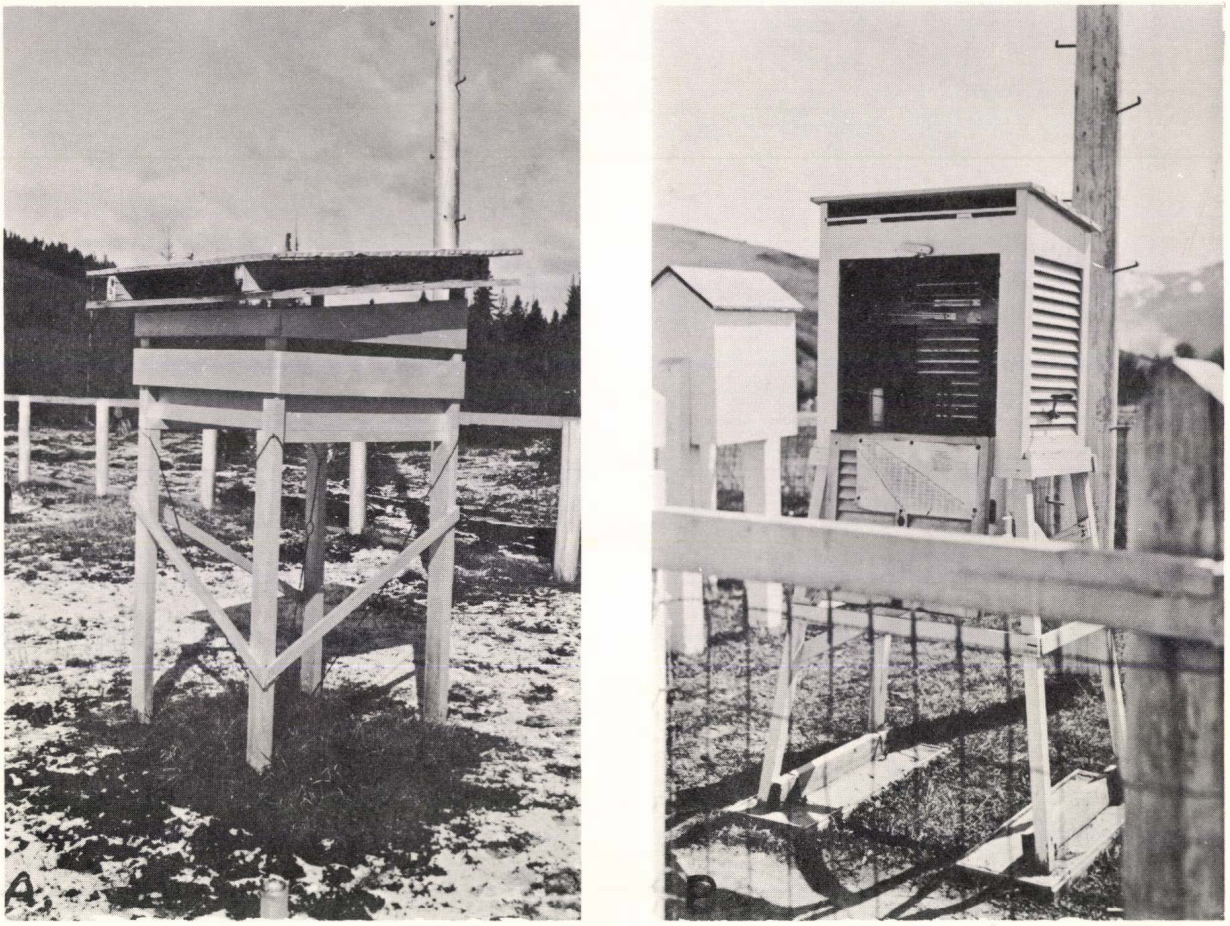


Figure 7. Two types of instrument shelters: A, Region 1 type; B, cotton region type.

Scale House

A scale house is necessary in order to obtain accurate fuel moisture readings. Where scales are in an instrument shelter there is often just enough breeze to prevent the scales from settling down and the observer is too likely to give up and enter his best guess on the record sheet. A standard scale house is shown in figure 8.

Mount the scale house solidly, with floor level, and with door away from prevailing wind. For easier weighing, replace wooden door panel with glass; cut a hole in right end of house just large enough so an arm can reach through to move weights on scale; hang a flap over this hole to protect the interior from dirt, birds, etc. As shown in figure 8, another method is use of a rod with a hook at one end to move the small sliding weight.

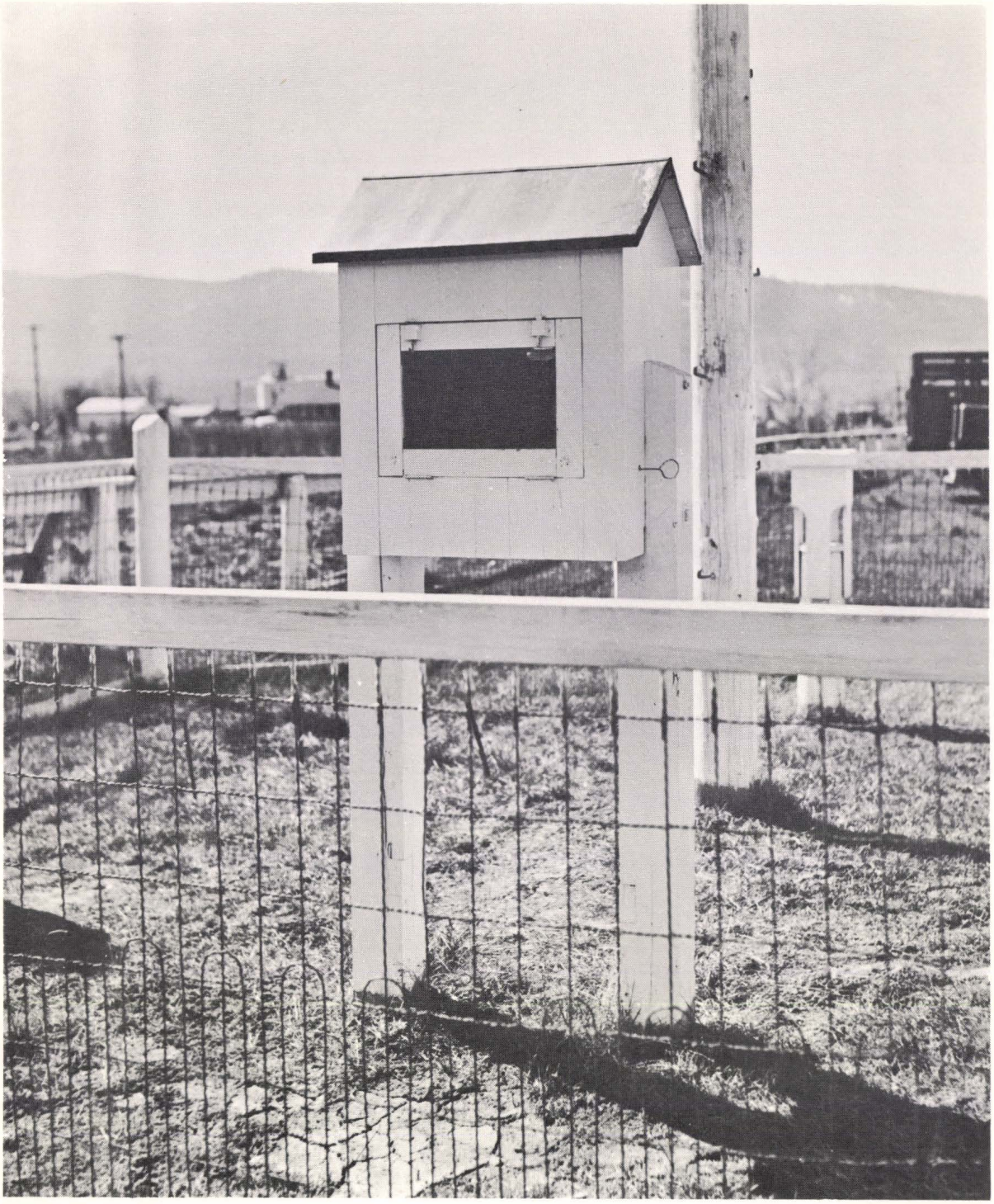


Figure 8. Scale house. Note wire, extending through right side, for adjusting the scales in windy weather.

Rain Gage

Two types of rain gages are used. At cooperative fire-weather stations the U. S. Weather Bureau furnishes a very accurate brass gage about 30 inches high. The Forest Service type is 12 inches high, made of galvanized stove pipe on the outside, and containing a brass measuring tube on the inside. Mount either type with the top of the gage 36 inches above the ground. Mount so the top of the funnel is level. Place the gage at a great enough distance from structures, trees, etc., so a 45° angle from the top of the gage will clear any obstacle. A stand for a U. S. Weather Bureau rain gage is shown in figure 10, right side.

Fuel Sticks, Screen, and Duff Bed

Fuel sticks are exposed to day-long sunlight under a screen and over a bed of duff or litter. The use of a screen produces a degree of shade for the sticks approximately equivalent to that existing on an old growth forest area from which three-fourths of the canopy has been removed. The duff bed approaches average forest conditions in relation to absorption, retention, and release of moisture. See figures 9 and 10.

Screen.--Use a double layer of 14-mesh wire screen held taut in a 3-foot-square frame. Hold screen 13 inches above the ground by means of a narrow support at each corner. Orient with cardinal directions.

Fuel sticks.--Place sticks on wire racks 10 inches above the ground under the north-central part of the screen. Arrange the sticks north and south--the hook end north, the printing up, the brads down.

Duff bed.--Cover the entire ground surface beneath the screen with a $\frac{1}{2}$-inch layer of dry coniferous needles sprinkled on top of the ground (not in a pit). Renew the duff each spring. Reduce weeds by sterilizing soil before new needles are put on.

Maintenance of Physical Plant

Maintain anemometer pole in a solid, sound, and vertical condition.

Keep anemometer support solid and vertical.

Keep duff bed the proper depth. Replace annually so a mulch won't be built up. Keep weeds out by pulling or poisoning.

Maintain a taut screen, no holes.

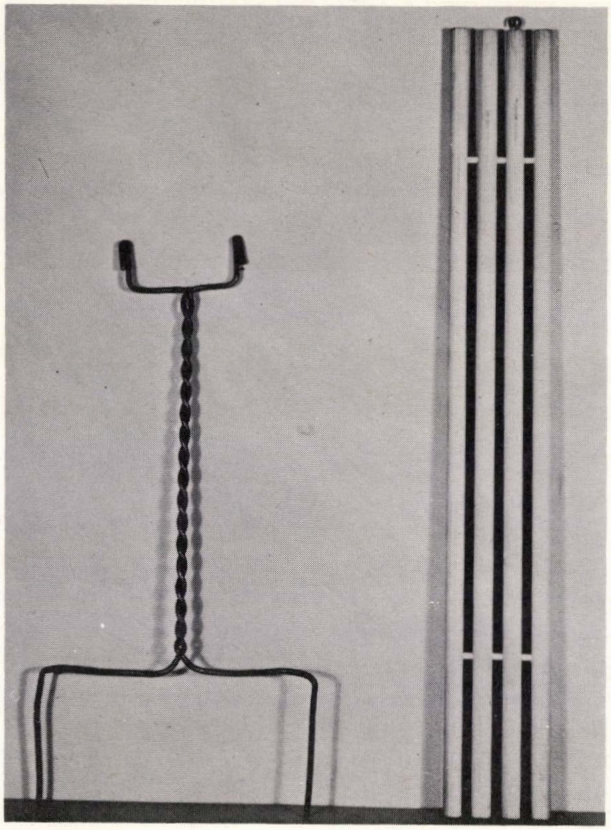


Figure 9. A set of $\frac{1}{2}$-inch fuel-moisture indicator sticks, and a wire rack for supporting 1 end of the sticks.

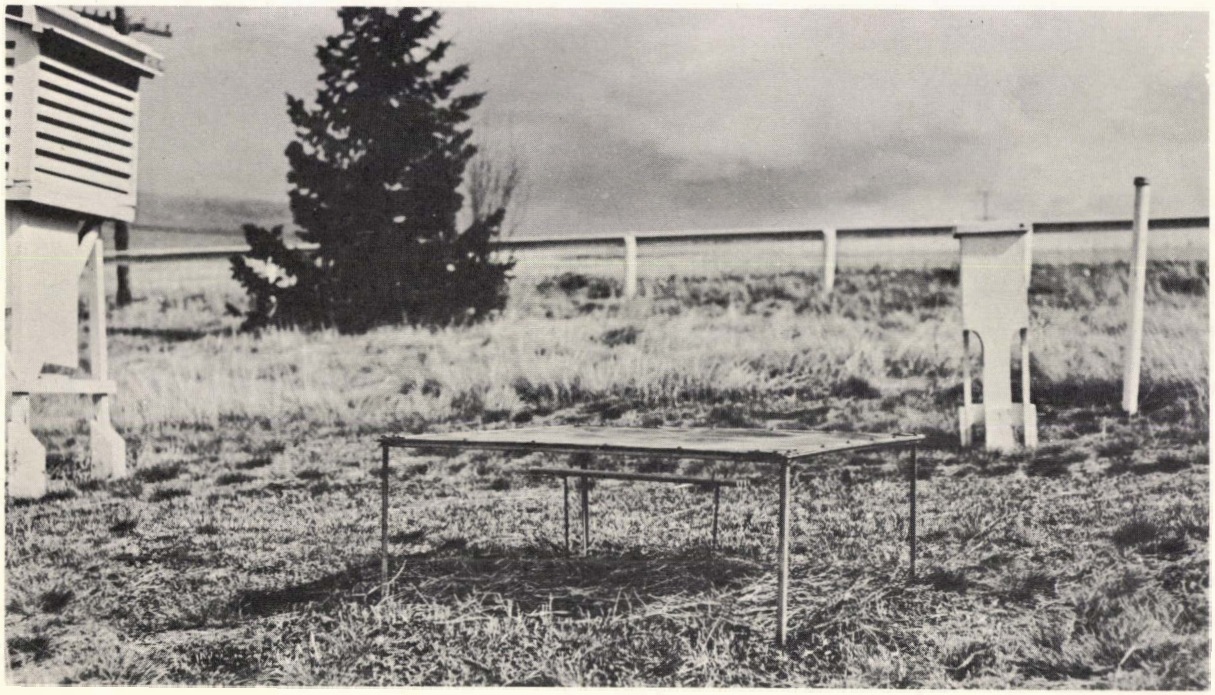


Figure 10. Screen, sticks, rack, and a duff bed.

Check the screen and sticks for proper height.

Maintain the scale and instrument shelters in a level and solid condition.

Encourage grass, but keep it under 4 inches in height. Keep it down around the edges of the fence also. Keep brush and trees down for 20 feet outside the fence.

Permit no sprinkling in close vicinity of the station.

Keep fence tight if station is bothered by people or animals.

Keep fire-danger station painted white. Especially keep the instrument shelter white.

Keep rain gage clean, its support solid, and the funnel top level.

Keep scale house clean--free from dust, spiders, birds.

FIRE-DANGER STATION INSPECTION

Standards of performance for a job must be established if that job is to be done correctly and consistently. This handbook presents guides for use and maintenance of fire-weather equipment. An inspection sheet for fire-danger stations is included in the appendix to serve as a tickler list and self-training tool for the observer's use in conjunction with the handbook. It may also serve as an inspection form for the forest officer's use in inspection and training. It can be used as a supplement to the regular lookout inspection form.

III. FIRE-WEATHER OBSERVATIONS

WHEN TO OBSERVE WEATHER

In Intermountain forests burning index is normally highest at about 1500 P. s. t. or 1600 m. s. t. during July and August. If measurements are taken within a period of 1 hour before or after this time the burning index will probably not vary more than 2 or 3 points.

Regardless of the time of year, measurements must be taken:

Before the sun goes down.

Before the temperature begins to drop.

Before the relative humidity begins to rise.

Recognizing these few limitations, the exact time for measuring the fire-danger factors is set by each forest or district for the fire-danger stations under its jurisdiction.

Establishment of a regular time to take fire-danger measurements should not prevent measurements being taken at any other time of day for such reasons as use on going fires, as a safety measure in critical weather, or as an aid in prescribed burning operations.

STANDARD FIRE-DANGER STATION OBSERVATIONS

Determination of a burning index with the Intermountain burning index meter calls for the measurement of only 3 items:

Fuel-moisture percent

Relative humidity

Wind velocity

The manner in which these measurements are used is explained on the recording form 120-INT and on the Model 8 Burning Index Meter.

For permanent record and for prediction purposes 2 other items of weather are recorded, but are not entered directly into the burning index computation:

Lightning occurrence

Precipitation

The following pages explain in detail how these measurements are made and recorded.

Form 120-INT

Form 120-INT serves 3 purposes:

It provides a form for recording information concerned with current burning index computations.

It brings together all current and forecasted data used in predicting the following day's burning index.

It becomes a permanent record for research and fire-control planning purposes.

A completely filled out form 120-INT is shown in figure 11. Complete instructions are printed on the back of the form.

Fuel-Moisture Measurement

Moisture content of small branchwood is determined by weighing a set of $\frac{1}{2}$-inch fuel-moisture sticks (figure 9). When bone dry, a set weighs 100.0 grams; thus the weight in excess of 100.0 is moisture.

As shown in figures 36, 38, and 39, 3 types of scales are used in measuring fuel-moisture sticks. The following instructions are for the triple-beam type. Variation in procedure for the Harvard balance and Appalachian types are noted following the triple-beam instructions.

Dust and balance the scales. If a 100-gram check weight is available, balance at 100 grams instead of at 0.

With clean glove, piece of cloth, or paper, remove sticks from underneath the screen. Do not scrape them on screen. If dry, lightly brush dust off. If wet, shake off any free moisture. Lay the center of the sticks across the CENTER of the scale pan. Put the weights IN the notches on the beams. Adjust small sliding weight on the front beam until the pointer travels, during its swing, the same amount on one side of the midpoint or 0 as it does on the other.

If scale is sluggish at all, tap main bearing cover with a finger or pencil so pointer will not settle prematurely in the wrong place.

Record the moisture content in percent on form 120-INT. Follow instructions on the back of the form.

Take weights OUT of notches.

Return sticks to their rack, same side up (brads down), and screw hook end north.

FIRE DANGER DAILY RECORD 120-INT

Instructions on reverse side.
Use separate sheet for each fire danger station.

Station EMERY R.S.
Forest St JOHN
Month August Year 1955

Sec. 15 T. 55N R. 12E Elevation 2492 Station no. 042701

Date	Today 1 Fuel stick moisture %	Today 2 5-day total FM %	Today 3 Severity index	Today 4 Relative humidity	Today 5 Wind, p.m. average	Today 6 Burning index	Today 7 Lightning past 24 hours	Today 8 Precipitation	Predicted** 9 Fuel stick moisture %	Predicted** 10 Severity index	Predicted** 11 Relative humidity	Predicted** 12 Wind, p.m. average	Predicted** 13 Burning index	Predicted** 14 Lightning (yes or no)	Predicted** 15 Precipitation (yes or no)	16	17	Last month 18 FM %	Last month 19 5-day total FM % (same as col. 2)	Date
1	3.9	22	9	21	6	59			4	9	20	5	56	No	No			5		
2	6.4	23	9	44	11	48			6	9	35	10	53	No	No			5		
3	5.9	24	9	31	10	53			6	9	35	10	53	No	No			4		
4	5.0	25	9	27	7	52			6	8	30	5	44	No	No			4		
5	7.3	28	8	44	5	35			7	8	40	5	37	No	No			4	22	1
6	5.3	29	8	32	10	53			7	7	35	10	45	No	No			6	23	2
7	5.1	28	8	31	6	47			6	7	40	10	45	Yes	No			6	24	3
8	4.9	27	8	28	9	52			6	7	30	10	50	No	No			5	25	4
9	4.7	27	8	24	9	55			5	7	25	10	55	No	No			7	28	5
10	4.7	25*	9	21	8	60			5	8	20	10	60	No	No			5	29	6
11	4.6	25	9	21	8	60			4	8	20	5	53	No	No			5	28	7
12	4.3	24	9	19	7	59			4	9	25	10	63	No	No			5	27	8
13	4.3	23	9	20	3	53	Yes		6	9	20	5	51	Yes	Yes			5	27	9
14	4.0	22	9	17	13	71			4	9	20	20	76	No	No			5	25	10
15	3.9	21	9	11	5	64			3	9	10	10	75	No	No			5	25	11
16	3.8	20	10	12	12	75			3	10	10	10	78	No	No			4	24	12
17	4.5	20	10	22	2	53	Yes	.05	4	10	15	5	64	Yes	Yes			4	23	13
18	5.8	22	9	24	4	49			4	10	15	5	64	No	No			4	22	14
19	12	30	8	48	7	30		T	7	9	50	10	45	No	No			4	21	15
20	50	76*	3	79	2	7	Yes	.38	40	5	65	5	12	Yes	Yes			4	20	16
21	32	104	2	85	9	9			50	2	80	15	11	No	No			4	20	17
22	21	121	1	53	1	4			50	0	70	5	3	No	No			6	22	18
23	17	132	0	34	6	15			20	0	30	5	13	No	No			12	30	19
24	11	131	0	24	1	17			14	0	25	0	16	No	No			50	76	20
25	8.7	90	2	27	3	24			10	0	20	3	22	No	No			32	104	21
26	6.5	69	4	21	5	39	Yes		15	1	25	5	19	Yes	Yes			21	121	22
27	6.3	49	5	18	4	44			9	4	20	5	33	No	No			17	132	23
28	6.3	38	6	17	6	49			6	5	15	10	55	No	No			11	131	24
29	7.1	34	7	23	7	44			7	6	20	10	50	No	No			9	90	25
30	7.5	33*	7	40	7	35	Yes	.02	10	6	35	15	39	Yes	Yes			6	64	26
31	6.9	34*	7	37	8	40	Yes	T	10	6	35	5	29	Yes	Yes			6	49	27
																		6	38	28
																		7	34	29
																		8	33	30
																		7	34	31

Worksheet for items 1 and 2. Use is optional.

*Check back through figures to make sure the 5-day totals are correct.
**Enter on date line for which prediction is being made.
Remarks: _____

Figure 11. Form 120-INT

INSTRUCTIONS

The instructions will be easy to use if they are followed one item at a time.

Columns 1 through 8 are for determining today's burning index.

Column 1. Fuel moisture percent. The weight in excess of 100.0 grams is the fuel moisture percent.
a. If between 0.0 and 9.4 percent, record to nearest 0.1 percent (e.g., 7.6).
If between 9.5 and 50.5 percent, record to nearest whole percent (e.g., 16). Round off .5 to nearest even whole number.
If over 50.5 percent, record as 50 (e.g., actual is 75.3, record only as 50).
b. If circumstances prohibit readings being taken for a day or two, an estimated fuel moisture percent must be entered in order for the severity index to be computed on the following days.
1. If the weather is settled and uniform, average the moisture content for the day on either side of those missed, and enter this average percent in the blank space or spaces.
2. If a break in the weather has occurred, use your best estimate for the missing days.
Following are a few examples of what might occur and how the missing data could be inserted:

	(Known) Friday	(Missing) Saturday	(Missing) Sunday	(Known) Monday
Settled weather	8.3	7.3	7.3	6.3
Rain on Monday	8.3	8.3	8.3	26.0
Rain on Sunday	8.3	8.3	25.0	16.0
Rain on Saturday	8.3	25.0	16.0	10.0
Rain on Friday	28.0	16.0	12.0	8.3

Column 2. Five-day total fuel moisture percent. Total up the fuel stick moisture percent for the last 5 days, including today. Use WHOLE numbers. If a fuel moisture percent number ends in .5, round it off to the nearest EVEN whole number (e.g., 6.5 to 6; 5.5 to 6). Use no daily fuel moisture percent of over 50 in computing the 5-day total. See columns 18 and 19.
During the first 4 days of record do this:
a. Average the fuel moisture percents for the number of days involved.
b. Multiply this number by 5.
c. That number will be used for the 5-day total fuel moisture percent.
d. Example:

Day	Fuel moisture content percent: Today's	Total	Average	Multiply by 5	Severity index
1st	6	6	6	30	8
2d	6	12	6	30	8
3d	8	20	7	35	7
4th	28	48	12	60	4
5th	17	65	--	--	4

Column 3. Severity index. Determine from step 1, Model 8 Burning Index Meter. The severity index is a number between 0 and 10 that corresponds to the total fuel moisture percent of the last 5 days. It indicates to what extent fire weather is building up toward a critical situation.

Column 4. Relative humidity. Record to nearest WHOLE percent.

Column 5. Wind, afternoon average. Measure three times during afternoon. Measure for at least 2 minutes each time. The number of buzzes per minute equals the miles per hour of wind velocity. Record to nearest WHOLE mile per hour.
For stations with dial- or chart-recording anemometers, report the average velocity from noon until report time.

Column 6. Burning index. Follow directions on the face of the Model 8 Burning Index Meter.

Column 7. Lightning during past 24 hours. Record only cloud-to-ground lightning within the protection area. Use "yes" or check mark. If no occurrence, leave the space blank.

Column 8. Precipitation during past 24 hours. Record to nearest .01 inch.

Columns 9 through 15 are for determining tomorrow's burning index, by incorporating (a) personal judgment, (b) fire weather forecast, (c) the burning index meter. Follow instructions on the Model 8 Burning Index Meter. Enter the data on the date line for which the prediction is being made.

Column 9. Fuel moisture percent. Use predicted precipitation, relative humidity and temperature to help you estimate it.

Column 10. Severity index. Compute in same manner as for column 3.

Column 11. Relative humidity. Change from today's reading by same amount that tomorrow's forecast is changed from today's forecast.

Column 12. Wind. Use forecast, as above.

Column 13. Burning index. Use burning index meter, as for column 6.

Column 14. Lightning. If predicted for tomorrow, enter "yes." If not, enter "no."

Column 15. Precipitation. If predicted for tomorrow, enter "yes." If not, enter "no."

Columns 16 and 17. Spare columns for local usage.

Columns 18 and 19 are included solely for the convenience of the observer. They don't have to be used. Here the observer can do his "scratch work" of rounding off, striking out 6-day-old figures, etc.

Column 18. Today's fuel moisture percent, rounded off. (See lines 2 and 3 of instructions for column 2.)
a. Enter today's fuel moisture percent to nearest WHOLE number. Provision is made at the top for carrying forward the fuel moisture percents of the last 4 days of the previous month so that continuity won't be lost.
b. Strike out the figure for the 6th day back, to prevent adding together more than 5 days' figures.
c. Add up the figures for the last 5 days, including today's.

Column 19. Five-day total fuel moisture percent.
a. Enter in this column, on the proper date, the 5 days' total as added up in column 18.
b. This total will then be entered in column 2.

General. The Fire Danger Station Handbook, Chapter III, Fire Weather Observations, contains more complete information on measuring and recording the fire weather factors and estimating tomorrow's burning index.

ONE LEGIBLE COPY OF THIS RECORD MUST BE SUBMITTED BY THE SUPERVISOR TO
THE INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION, FOREST FIRE LABORATORY, MISSOULA, MONTANA, BY NOVEMBER 10.
IF THE ORIGINAL COPY IS READABLE, IT IS NOT NECESSARY TO MAKE AN EXTRA COPY; SEND THE ORIGINAL.

Variation in procedure for Harvard balance.--Figure 38 shows how the weights are used. There are no notches on the beams for the weights in this type of scale.

Variation in procedure for Appalachian scale.--Check balance by hanging a 100-gram weight on the hook at the left end of arm. Now move slide along the arm until the pointer is at 0. Tap hub so the arm will come to rest accurately. If scale is mounted vertically and squarely, slide will be very close to the 100 mark on arm.

Use screw hook to hang sticks on wire hook.

Read moisture content in percent as indicated by pointer on the scale.

Relative Humidity Measurement

Relative humidity is the amount of water vapor in the air compared to the maximum amount of vapor the air can hold at a given temperature. It is expressed in percent.

A psychrometer is used to measure relative humidity. It consists of 2 ordinary thermometer tubes. A thin cotton wicking is placed over the bulb of 1 tube. When wicking is wet and air passes over the tubes, evaporation from "wet bulb" tube will cause its temperature to drop. The lower the relative humidity, the more the evaporation; thus a greater spread between the temperatures of the 2 tubes. Tables are used to convert the readings from the 2 thermometers to the proper relative humidity percent (see appendix).

The types of psychrometers used are illustrated in figure 34.

Sling psychrometer operation instructions.--Wet the wicking thoroughly with clean water of about air temperature.

Stand in the shade. Do not let sunlight or rain strike the thermometers.

If light conditions permit, face the wind so body heat will not influence the temperature of the thermometers.

Stand away from doorway or open windows; moisture and temperature conditions inside a building are not the same as in the free air.

Whirl for about 1 minute at the rate of 200 whirls per minute. BE CAREFUL, as the thermometer breaks easily.

Never touch thermometer tubes with the hands.

Read wet bulb.

Whirl another 40 or 50 times, and read again.

If wet bulb temperature is lower than before, continue to whirl and read until it will not go any lower.

When the lowest point is reached, read the wet bulb. Then immediately afterward read the dry bulb.

Round off the readings to nearest degree. If both thermometers read a fractional degree, round them both off in the same direction.

Fan psychrometer operating instructions.--The process is the same except that the fan is turned until the wet bulb remains at the lowest point for several seconds. Then proceed with the readings.

Relative humidity table use.--Select the table that has an elevational range embracing the station's elevation.

Read across from the dry bulb temperature and down from the wet bulb temperature.

Read the relative humidity in percent at the intersection.

If the humidity is under 10 percent, repeat the entire process as a check to make certain that this unusually low reading is correct.

Wind Measurement

The amount of wind going past a fire-danger station is measured by an anemometer. Some anemometers add up on a dial the total number of miles of air that goes past. Others, through electrical contacts, transmit the information to a buzzer; in this type the observer must count the buzzes for a specified length of time. The buzzer contact closes once for each one-sixtieth mile of wind that passes by. Thus the buzzes counted for one minute represent the wind velocity in miles per hour. The buzzer-type is by far the most common at fire-danger stations.

The average wind for the afternoon is used in determining the burning index. Following are instructions for recording wind.

Buzzer-type anemometers.--See figures 29 and 30. Measure the wind 3 times between noon and the time the afternoon fire-danger measurements are taken. Use a predetermined schedule such as 1200, 1400, 1600, or 1200, 1330, 1500. (Don't deviate from the schedule in order to record gusts). See figure 12.

AFTERNOON AVERAGE WIND

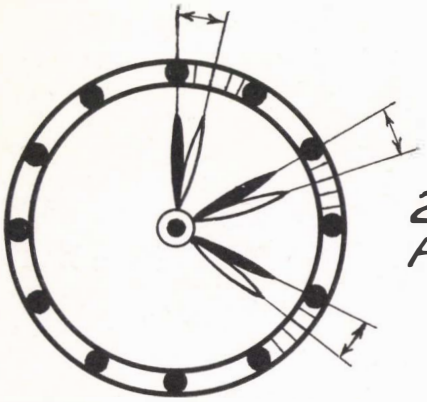


Figure 12. Measure wind 3 times during the afternoon for 2 minutes each time.

Count all buzzes that occur during a period of exactly 2 minutes.

Divide the buzzes by 2 to arrive at the average miles per hour.

Do this 3 times during the afternoon, and determine from these 3 readings the afternoon average wind velocity.

Dial-type anemometers.--Read the dial at 1200, and again at measurement time, preferably an even number of hours after the first reading.

Subtract the earlier reading from the later one.

Divide this difference by the number of hours that have elapsed to obtain the afternoon average wind.

For information on reading the dial-type anemometer, refer to figure 13. The dials are composed of 2 thin wheels, 1 rotati on top of the other. The inner dial is graduated in tens and hundreds of miles. The outer dial is graduated in miles and tenths of miles.

Read the inner dial first. The index for the inner dial is located on the outer dial. It is a small "zero" through which is drawn a vertical line. In figure 13 the index is between 470 and 480 miles.

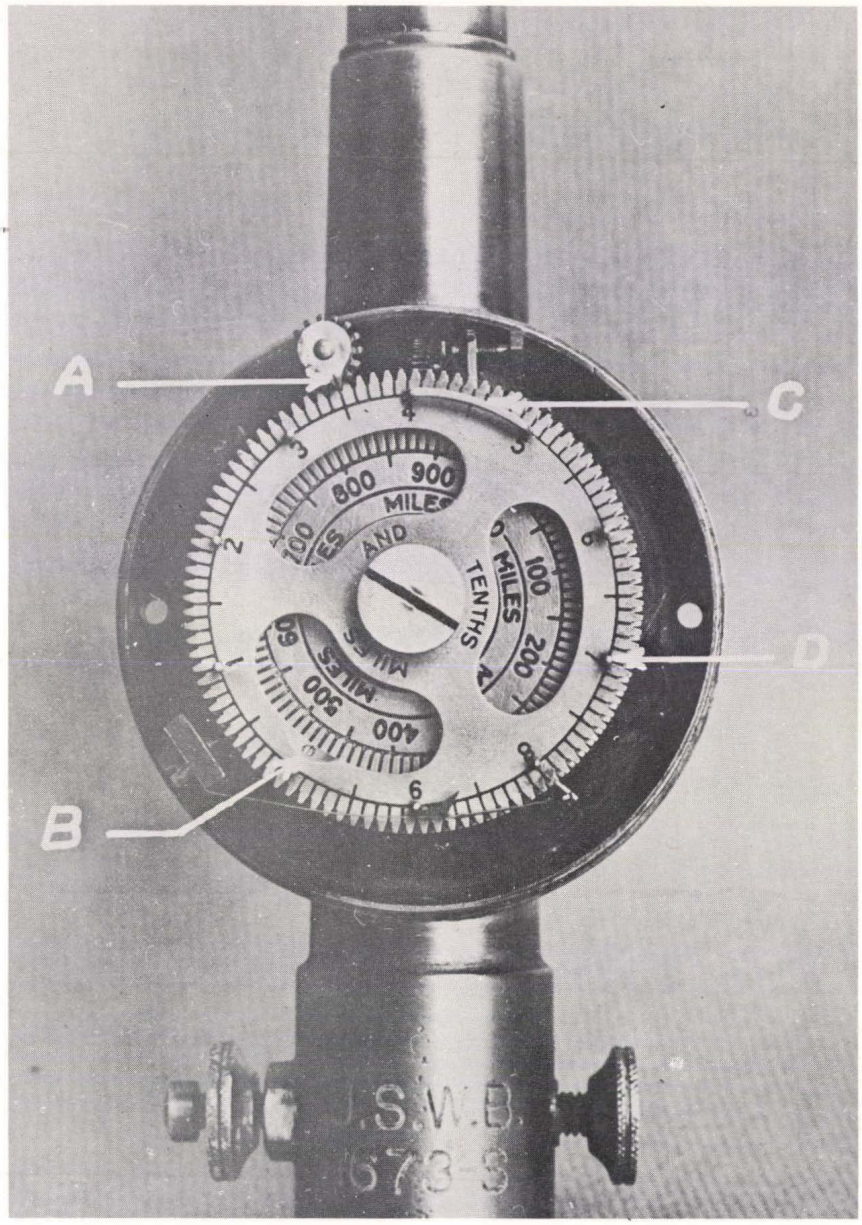


Figure 13. Dial-type anemometer with cover removed. The reading is 473.5 miles (470 on inner dial, and 3.5 on outer dial): A, 1/10-mile index; B, 10-mile index; C, 10-mile bar; D, 1-mile pin.

The second index is a small pointer located above and just to the left of the large dials. This index will point to some mile or tenth of mile on the outer rim of the outer dial. In figure 13 the pointer is located on the fifth division between 3 and 4; therefore it indicates

3.5 miles. With the cover on, the eye has to be lowered slightly to see this second index. The total reading is arrived at by adding the miles indicated on the outer dial (3.5) to the miles indicated on the inner dial (470) making a total of 473.5 miles of wind.

At some stations a recorder will be used with this type of anemometer. The mile contact is activated by pins at the mile intervals on the outer dial. A solid bar between numbers 4 and 5 causes an extra long contact once every 10 miles. A simplified procedure for reading these charts is to count only the long bars made by the recording pen and multiply by 10 to obtain the total miles of wind movement. If each mile is counted, the long bar is worth 2 miles, as no break registers on the chart between these 2 points. See figure 13, C and D.

Lightning Observation

Recording of cloud-to-ground lightning is an important item in fire-weather observation and fire-danger rating. A fire dispatcher needs to know when and where lightning occurs within his protection area. He needs to know the path that the lightning took and approximate number of strikes. He also needs to know the amount of precipitation occurring along with the strikes.

Cloud-to-cloud lightning will not increase the danger of fires starting. Thus, only cloud-to-ground lightning need be recorded on form 120-INT

Precipitation Measurement

It is important to observe not only the total amount of precipitation, but the manner in which it falls. A slow, drizzly rain will probably wet fuels down more and last longer than will a hard short duration thundershower of the same amount.

It is important also for the observer to note the path of a storm and to observe in general amount and type of precipitation coming from it, even when none falls at his station. This information is valuable to the dispatcher in event a fire starts in the vicinity of the storm.

Instructions for measuring normal amounts of rain.--See figure 40. Remove funnel top from the rain gage.

Lower clean measuring stick into measuring tube slowly, to prevent water splashing up on stick.

Remove stick before water has a chance to soak up above actual water line.

Read stick in inches and hundredths. For all precipitation measurements any amount less than one-half of .01 inch is recorded as a trace (T).

Dump water out of measuring tube.

Measuring rain where measuring tube has overflowed.--Record full tube as .50 for U. S. Forest Service type, or 2.00 inches for U. S. Weather Bureau type.

Carefully lift tube out and dump the water.

Pour water from the overflow can into measuring tube and measure.

The sum of these measurements is the precipitation for the period.

Measuring procedure when snow is expected.--Remove funnel top and measuring tube.

At measuring time warm overflow can just enough to melt snow but not enough to evaporate any water.

Then pour water into the measuring tube and measure it.

Night or early morning rains.--Often rain will fall during the night or early morning. If this is not measured until 1500 or 1600, some of it may have evaporated. Therefore, measure such rains as soon as possible after rain stops. The sum of all measurements since the one at recording time the day before is the total precipitation for the period.

Burning Index Computation

The Model 8 Burning Index Meter provides the medium for integrating the fire-weather factors into a single usable figure. Four items of information can be obtained from the meter:

Severity index showing cumulative fuel moisture trends.

Burning index at the station where the factors were measured.

Conversion of burning index to another position, exposure, and time.

Prediction instruction for estimating tomorrow's burning index.

Instructions on the meter, combined with those on the back side of form 120-INT, provide the necessary guides for computing burning index (figures 14 and 15). Specific examples are as follows.

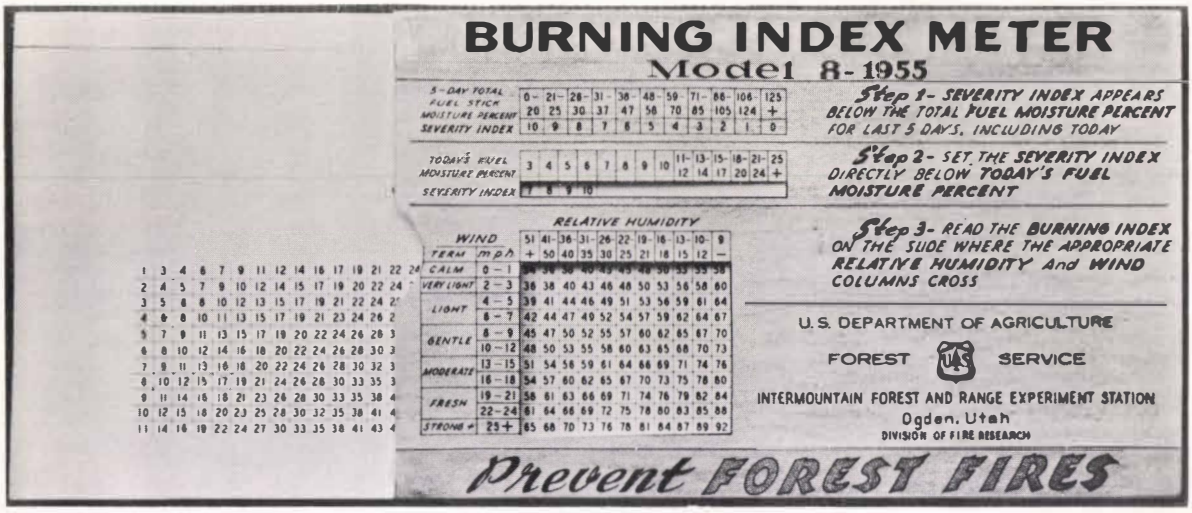

BURNING INDEX METER
Model 8-1955
Step 1- SEVERITY INDEX APPEARS BELOW THE TOTAL FUEL MOISTURE PERCENT FOR LAST 5 DAYS, INCLUDING TODAY
Step 2- SET THE SEVERITY INDEX DIRECTLY BELOW TODAY'S FUEL MOISTURE PERCENT
Step 3- READ THE BURNING INDEX ON THE SLIDE WHERE THE APPROPRIATE RELATIVE HUMIDITY And WIND COLUMNS CROSS
RELATIVE HUMIDITY
WIND
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah
DIVISION OF FIRE RESEARCH
Prevent FOREST FIRES

Figure 14. The burning index meter (front side).

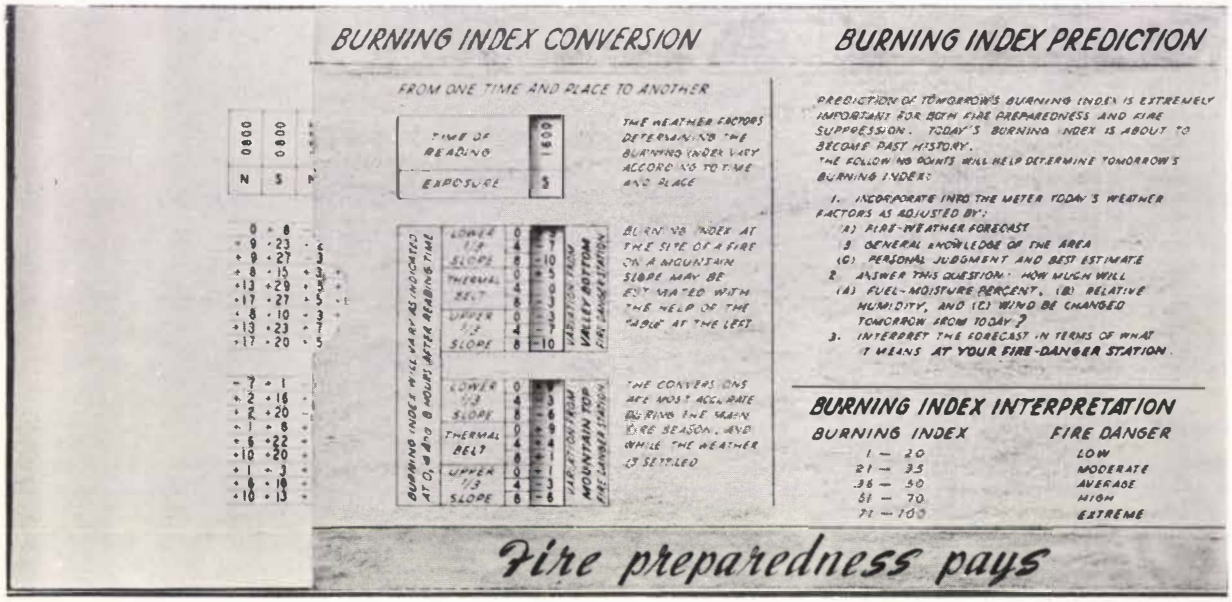

BURNING INDEX CONVERSION
FROM ONE TIME AND PLACE TO ANOTHER
TIME OF READING
EXPOSURE
THE WEATHER FACTORS DETERMINING THE BURNING INDEX VARY ACCORDING TO TIME AND PLACE
BURNING INDEX AT THE SITE OF A FIRE ON A MOUNTAIN SLOPE MAY BE ESTIMATED WITH THE HELP OF THE TABLE AT THE LEFT
THE CONVERSIONS ARE MOST ACCURATE DURING THE MAIN FIRE SEASON, AND WHILE THE WEATHER IS SETTLED
BURNING INDEX PREDICTION
PREDICTION OF TOMORROW'S BURNING INDEX IS EXTREMELY IMPORTANT FOR BOTH FIRE PREPAREDNESS AND FIRE SUPPRESSION. TODAY'S BURNING INDEX IS ABOUT TO BECOME PAST HISTORY.
THE FOLLOWING POINTS WILL HELP DETERMINE TOMORROW'S BURNING INDEX:
1. INCORPORATE INTO THE METER TODAY'S WEATHER FACTORS AS ADJUSTED BY:
(A) FIRE-WEATHER FORECAST
(B) GENERAL KNOWLEDGE OF THE AREA
(C) PERSONAL JUDGMENT AND BEST ESTIMATE
2. ANSWER THIS QUESTION: HOW MUCH WILL (A) FUEL-MOISTURE PERCENT, (B) RELATIVE HUMIDITY, AND (C) WIND BE CHANGED TOMORROW FROM TODAY?
3. INTERPRET THE FORECAST IN TERMS OF WHAT IT MEANS AT YOUR FIRE-DANGER STATION.
BURNING INDEX INTERPRETATION
BURNING INDEX
FIRE DANGER
1 — 20 LOW
21 — 35 MODERATE
36 — 50 AVERAGE
51 — 70 HIGH
71 — 100 EXTREME
Fire preparedness pays

Figure 15. The burning index meter (back side).

Burning index.--Assume:

Fuel moisture on each of last 5 days has been 5 percent.

Fuel moisture today is 5 percent.

Relative humidity today is 14 percent.

Wind this afternoon averages 11 m. p. h.

Step 1. 5-day total fuel moisture is 25. Severity index is thus 9.

Step 2. Slide is pulled out so that a severity index of 9 is directly under today's fuel moisture of 5 percent.

Step 3. Without further movement of the slide, read down the relative humidity column of 13-15 percent, and across the wind column of 10-12 m. p. h. A burning index of 68 is at the intersection.

The meter in figure 14 is set up for the solution of this problem.

Burning index conversion.--Assume:

The valley bottom fire-danger station burning index of 68 is taken at 1600. A fire is in the thermal belt (halfway up a major slope), on a southern exposure. What will be the burning index at the fire at midnight?

Use back side of meter. Pull slide out so 1600 appears at "Time of Reading" window, and S appears at "Exposure" window.

In the next window down, "Variation from Valley Bottom Fire-Danger Station," read the number "-3" opposite "Thermal Belt" and "8" (for 8 hours after time of the reading, or 1600 plus 8 = 2400).

68 minus 3 is 65, the burning index at the fire at midnight. Meter in figure 15 is set up for solution of this problem.

Burning index prediction.--Keen observation of local conditions and proper use of accurate weather forecasts can be combined to make general predictions of tomorrow's burning index. The factors making up today's burning index are known. The U. S. Weather Bureau's evening fire-weather forecast gives a good idea of what changes might take place in these factors for tomorrow. Where no evening forecast is available, the following morning's forecast can be used for estimating the burning index for that afternoon. The following points may assist in predicting tomorrow's burning index:

Tomorrow's temperature and humidity are forecast.

Tomorrow's wind is forecast.

If the forecast indicates warmer and drier weather than today's, it may be assumed that fuel moisture and relative humidity will decrease.

If cooler and more moist weather is forecast, it can be assumed that fuel moisture and relative humidity will increase.

If just after a rain, and dry weather is forecast, fuel moisture may drop 2 or 3 columns to the left on the meter.

Or, if the past few days have been dry, but rain is forecast, fuel moisture may be read 2 or 3, or even more columns to the right on the meter.

The severity index will vary in a smiliar manner. Examples:

	Date	Relative Humidity	Wind	Fuel Moisture	Severity Index	BI
Today	7/8	22	7	6	7	47
Forecast for	7/9	35-40	5	8	6	31
Today	7/21	80	3	22	3	9
Forecast for[1]	7/22	35-40	8	13	4	24
Today	8/5	28	3	6	7	38
Forecast for	8/6	15-20	10	5	7	60
Today	8/10	21	16	5	9	70
Forecast for[2]	8/11	70-80	6	20	6	19

1/ Also clearing
2/ Also rain

Today's burning index, weighted by the forecast for tomorrow, should for most days give a far better estimate of tomorrow afternoon's fire-weather conditions than if a rough guess alone were used. Remember that a forecast is made for an average location. One station will often have consistently more severe weather than the forecast indicates, and another station will consistently have more mild weather. These differences should be learned; then, in using the forecasts, the amount of change from the present will be the important thing, not the numbers themselves.

Form 124-INT (Revised 1955)

Form 124-INT is a chart for recording burning index for the period May 1 through October 31. It is used primarily by the district ranger to keep a graphic record of the daily average burning index on his district. The figure to use is determined by first averaging the burning indexes of the mountaintop stations, then averaging this figure with the valley bottom station burning index, e. g.,

Double Arrow Lookout 65)
Falls Point Lookout 55) 60
Seeley Lake R. S. 52 52
112, or a district average of 56.

(Average only the burning indexes, not each factor.) Use of the graph facilitates observation of the buildup of the season and the effects of easy and of critical periods of weather.

Form 124-INT is also often used in the supervisor's office to record the average daily burning index of the entire forest. This is a straight average of all district averages.

STANDARD FIRE-WEATHER STATION OBSERVATIONS

Information collected at a fire-weather station includes all that was described in the previous section, plus that which is necessary to fill out form 1009-E, the U. S. Weather Bureau 10-day fire-weather record. This section will describe the use of the maximum and minimum thermometer and the hygrothermograph, and will explain the proper way to complete form 1009-E.

Maximum-Minimum Thermometer

The maximum thermometer records the highest temperature, and the minimum thermometer records the lowest temperature since it was last set. Figure 16 indicates the correct procedure for reading and setting the thermometers.

Read the minimum thermometer as soon as the instrument shelter is opened. Reset it after all other work is done.

Under item 3 in figure 16, make certain the mercury column is down against the constriction at the bottom of the tube before whirling. If it is not, the constriction is liable to be ruptured.

If trouble is experienced with the mercury column retreating in the maximum thermometer, or with the mercury or alcohol column separating in either the maximum or minimum thermometer, refer to Chapter IV for corrective measures.

Hygrothermograph

The hygrothermograph mechanically maintains a continuous record of relative humidity and temperature. It renders accurate relative humidity data only if checked at least once a week with a sling psychrometer. The temperature record is much more reliable. For consistently good results, become familiar with the care and adjustments for the instrument, as described in Chapter IV.

Instructions for normal operation follow:

Reading the chart.--The chart is divided into 2 parts. The lower part records relative humidity, and is marked from 0 to 100 percent. The upper portion records temperature; the range of temperatures on the chart varies, lower for winter than for summer operation. The chart is also marked off in 2-hour periods from midnight to midnight. Each chart contains a week's record.

Changing the chart.--The name of the weather station and the inclusive dates of record must be on each chart. Change chart on Monday at 0800.

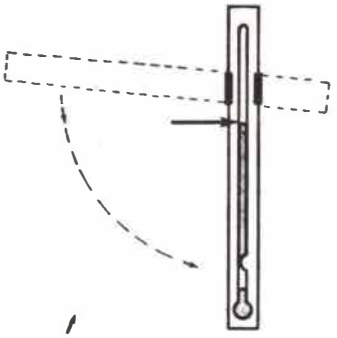
READING AND SETTING THERMOMETERS

1. MINIMUM TEMPERATURE—

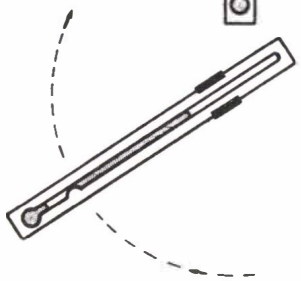
Read right end of index in minimum thermometer.

2. MAXIMUM TEMPERATURE—

Unlock and slowly lower maximum thermometer; then read top of mercury column.



3. Whirl maximum thermometer until its reading agrees (within 1°) with reading at top of alcohol column of minimum thermometer.

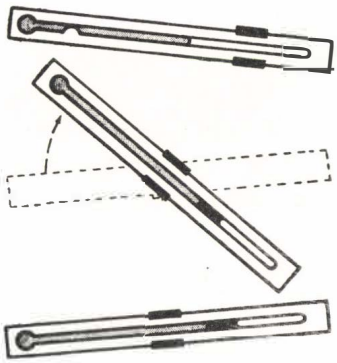


4. Do not lock maximum into position, or reset minimum or place it in position until all other work in the instrument shelter is finished. Vibrations or jars will jiggle the minimum index out of place.

5. Lock maximum in position.

6. Invert minimum until index drops to end of alcohol column.

7. Return minimum to its nearly horizontal position.



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U. S. WEATHER BUREAU

Figure 16. Reading and setting maximum-minimum thermometers.

Lift pens off the chart, using throw-out lever.

Remove clock from its spindle.

Pull clip out and remove old chart.

Wind clock until nearly tight.

Place the new chart down against the bottom rim of clock. Put the beginning end on the underside; adjust it so the clip will just cover the end of the chart. Make chart tight all around and replace clip.

Replace clock on the spindle, just a little fast of correct time.

Then turn clock counterclockwise to the correct time, to take up slack in the gears. (Friction-mounted gears make it possible to turn clock slightly without lifting clock up.)

Re-ink pens and lower them to the chart. Check ink flow by turning clock back and forth.

Inking the pens.--Use only the purple glycerine base ink provided for the hygrothermograph by the U. S. Weather Bureau.

Fill pen until the ink just shows at each end. If filled until it bulges out, the chart may become overinked.

Two or 3 drops usually fill a pen.

In damp weather the ink picks up moisture; so put less ink in the pens, and keep the pen points sharper.

To start the flow of ink, draw a piece of chart paper through the points to clean out old residue and to draw the ink film out to the points.

Difficulty often occurs in getting ink out of the bottle on the small pin that is attached to the stopper. Remove stopper from bottle quickly and smoothly, not touching the sides; this will prevent the ink from draining into bubbles in neck of bottle.

Form 1009-E

Form 1009-E is a U. S. Weather Bureau form maintained at cooperative fire-weather stations. The information collected becomes part of the permanent record of the Weather Bureau and of fire research units of the Forest Service. The data are now being entered on I B M punch cards; thus a high degree of accuracy in recording the data is important. While this form duplicates several items that appear on form 120-INT, it covers many other items of daily fire weather in considerable detail. See the sample filled out form 1009-E in figure 17.

Form 1009-E (See instructions on cover)

Forest or Agency St Joe
County Shoshone State Idaho
Station and Number Avery R.S. 040401
Section 15 Twp. 45N Range 5E
Meridian Boise

U. S. DEPARTMENT OF COMMERCE
WEATHER BUREAU
10-Day Fire-Weather Record

Elevation (feet) 2492
Pres. Table 27" ✓
TIME USED (check one): PST ✓ MST CST EST

Month August
Year 1954
Dates 11 To 20, incl.

Date	Time a. m. TEMPERATURE Maximum	Minimum	DRY	WET	Dewpoint	REL. HUM.	WIND DIR. (from)	VELOCITY	STATE OF WEATHER	CLOUDS Amount (tenths)	Kind	DIR. (from)	Visibility	Percent Fuel Moisture	Time p. m. TEMPERATURE Maximum	Minimum	DRY	WET	Dewpoint	REL. HUM.	HYGRO. CHECK Temp.	Rel. Hum.	WIND DIR. (from)	VELOCITY	STATE OF WEATHER	CLOUDS Amount (tenths)	Kind	DIR. (from)	Visibility	Percent Fuel Moisture
Instr.	1	2	3	4	5	6	11	12	14	28	29	30	31	32	1	2	3	4	5	6	9	10	11	12	14	28	29	30	31	32
11															85	40	84	59		21	84	21	SW	8	C	0				4.8
12															90	43	86	63		28	86	27	SW	7	C	0				4.6
13															92	49	79	64		59	74	58	C	0	OC	10	2	W		5.6
14			Use this section only when												84	47	79	63		42	79	43	SW	13	BC	6	2	W		6.0
15			morning observations are required.												80	46	69	58		52	69	52	SW	5	BC	6	6	SW		14.0
16															80	46	66	55		50	66	51	C	0	BC	9	6	W		13.0
17															71	46	68	58		56	68	56	E	2	BC	7	3	E		15.0
18															82	47	76	61		43	76	42	SW	4	SC	5	2	SW		8.0
19															77	43	65	60		76	65	76	SW	7	OC	10	5	SW		12.0
20															66	54	61	57		79	61	80	SW	2	OC	10		SW		50.0
31																														
Sums																														
Means																														

Date	HUMIDITY Highest	Lowest	Prevailing Wind Direction (day)	Character of Day	PRECIPITATION Kind	Time Began	Time Ended	AMOUNT a. m.	p. m.	24 HR.	Snowfall	Snow Depth on Ground	No. Days Since Last Precipitation	THUNDERSTORMS INTENSITY	Time First Observed	Time Last Observed	Condition of Vegetation				81
Instr.	7	8	13	15	16	17	18	19	20	21	22	23	24	25	26	27	40	36	37	38	39
11	98	21	SW	C																	71
12	100	28	SW	C																	60
13	96	25	C	OC	R	1100	1115			T				M	1045	1130					36
14	100	34	SW	OC																	60
15	100	46	SW	BC	R R	1100 2200	1600			.07				MT SV	1100 2200	1630					18
16	100	45	SW	BC	R		0300			*				SV		0400					14
17	100	49	SW	BC	R	1430	1515			.08				MT	1415	1515					12
18	100	32	SW	SC																	24
19	100	42	SW	OC	R R	— NP	—			T				M	NP						16
20	100	66	SW	OC	R R	1400	NA 1415			T				M		NA					7
31																					
Sums					Number of days* .01"+	.10"+	.25"+	.50"+							No. thunderstorm days * Mean decade temp. *						
Means																					

REMARKS 41

Notes:

Item No:

17, 18, 26, 27. Use 24-hour clock.

11. If calm, record "C" instead of "0"

21. If away from Station, enter "*" to indicate data are included in next report.

28. If less than .1, enter "0".
If over .9, enter "10".
If sky obscured by fog, enter "10".
If sky obscured by smoke or haze, enter "—".
Use a dash (—) only to indicate missing data.

29. Cu clouds only. See text for classification.

Computed by _____ Date _____ Checked by _____ Date _____ Observer John Smith P. O. Address Avery, Idaho

*Observer leave blank.

16—18279-1

Figure 17. U. S. Weather Bureau Form 1009-E.

Use the small booklet, Fire-Weather Observers' Daily Memoranda, Weather Bureau Form No. 1011 A, while taking the measurements.

Excellent instructions are printed on the cover of each pad of 1009-E. However, more complete instructions are included here for some items that have caused confusion or misinterpretation. Also, due to the recent initiation of processing this form onto punch cards, some changes in instructions have been made. Where differences occur between instructions here and on the pad covers, use those in this handbook.

Use the 24-hour clock in recording time.

The time of the afternoon observation is the same as for form 120-INT. Morning observations will be at 0800, where they are requested.

Enter afternoon observations in right hand side of the form. Enter morning observations in left hand side of the form.

Begin entries on proper date line.

Allow space for days when no entries are made.

Use a dash "--" only to indicate missing data.

Column 1.--Today's maximum temperature must be at least as high as the dry bulb temperature for either yesterday or today.

Column 2.--Today's minimum temperature must be at least as low as the dry bulb temperature either for yesterday or today.

Column 5.--Leave blank.

Column 9.--Read the current temperature from chart. Then move temperature pen a short distance up or down on the chart to mark exactly when observation was made.

Column 10.--Do the same as for column 9. Check reading against psychrometer reading. If a large difference exists, recheck psychrometer. If the error still exists, adjust hygrothermograph as explained in Chapter IV.

Column 11.--If calm, record "C."

Column 12.--Record to nearest whole unit. Record velocity at observation time.

Column 28.--Estimate tenths of sky covered with clouds as if the clouds were all pushed together on one side of sky.

If less than one-tenth of sky is covered with clouds, enter "0."

If over nine-tenths of sky is covered with clouds, enter "10."

If sky is obscured by fog, enter "10."

If sky is obscured by smoke or haze, enter a dash, "--."

Column 29.--Leave blank.

Column 30.--Leave blank.

Column 31.--Leave blank.

Column 32.--Enter in units and tenths, e.g., 5.6, 9.2, 13.0, 50.0. Indicate decimal points clearly.

Columns 7 and 8.--Enter tentatively, as it may change between observation time and midnight. Enter for the period midnight to midnight.

Columns 17 and 18.--Enter on proper date line the time precipitation actually began or ended. Midnight-to-midnight basis.

Column 21.--Enter the total precipitation since the last measurement. Record as of observation time. If away from station, enter "*" to indicate data are included in next report.

Columns 26 and 27.--Same as for columns 17 and 18. Enter any type of lightning, cloud-to-ground or cloud-to-cloud, or of thunder that occurs over the area for which the observer is responsible--usually a ranger district.

Column 40.--Leave blank.

Column 39.--Record the current burning index for that weather station. Entry in any other column will preclude its being punched.

At observation time fill out only tentatively columns 7, 8, 16 to 18, and 25 to 27. If either precipitation or thunderstorm activity occurs after observation time and before midnight, enter it the next day, but on the date of actual occurrence.

CLOUD OBSERVATIONS

A sound knowledge of cloud types can help a fire-control man in many ways. He will have a better chance to foresee such things as lightning, sudden gusts of wind, rainstorms, or possible sustained high winds.

From a fireman's standpoint, clouds are classified as cumulus (vertical development), middle (alto), and high (cirro). Middle clouds normally lie within a layer between 15,000 and 25,000 feet above sea level. High clouds normally lie between 25,000 and 35,000 feet above sea level.

Cumulus cloud bases vary widely from the mountaintops to about 18,000 feet above sea level; the tops may rise to an altitude between 30,000 and 50,000 feet. They may range anywhere from a small, fluffy fair weather cumulus to a sky-enveloping heavy black-based thunder and lightning storm.

Vertical Development Clouds--Cumulus

The development of a cumulus cloud can be segregated into 6 stages.

1. Fair weather cumulus.--(Figure 18.) Flattened, little vertical development, horizontal bases, rounded upper surfaces; usually small and scattered.

2. Towering cumulus.--(Figure 19.) Dark, horizontal bases, great vertical development, often in form of towers or of complex heaps with "cauliflower" formation; upper surfaces look hard and are clear cut.

3. Ice-top cumulus.--(Figure 20.) Great vertical development, tops composed, in part at least, of ice crystals as denoted by a lack of definiteness that the towering cumulus showed. Some may have a clearly fibrous, often anvil-shaped top, but the name is applied to any cumulus type which definitely has ice at the top, even if it does not have the anvil top.

4. Virga.--(Figure 21.) Precipitation falling from a cumulus cloud, but not reaching the ground.

5. Rain.--(Figure 22.) Precipitation falling from a cumulus cloud and reaching the ground in liquid form.

6. Thunderstorm.--(Figure 23.) An ice-top cumulus cloud that is producing lightning and thunder.

Middle and High Level Clouds (Alto and Cirro Types)

For informational purposes, some of the other major types of clouds are illustrated in figures 24 to 28.

Altocumulus castellatus.--(Figure 24.) The base of the clouds is between 20,000 and 30,000 feet. They occur in small patches, generally in the forenoon. Their presence is important to observe because very often thunderclouds will occur within the next few hours.

Altocumulus and cirrus--jet stream indicators.--(Figures 25 to 28.) The appearance and speed of movement of these clouds are indications of the speed of the airflow at 20,000 to 30,000 feet altitude. The jet stream is a band of high velocity air, typically 50 to 100 miles wide, and several miles thick, at an average altitude of 7 miles. The jet stream means a strong wind, and a strong wind means a strong vertical wind shear. The shear tends to draw cirrus wisps out into long lines, put ripples and wavelets on other clouds, and create wave clouds such as altocumulus lenticulars. Thus the jet stream should make its presence known by its effect on middle and high cloud structure.

Classification is on the basis of whether the cloud "looks fast" or "looks slow." High and middle level clouds "look fast" if they are firm, long and drawn out, or have prominent rolls, ridges, or waves in them. In the case of altocumulus lenticular clouds, which often are fixed with respect to the ground and take their over-all shapes from the ground topography, and which rarely contain a substructure of wavelets, "fast" means a hard appearance, with firm edges, indicative of a strong wind blowing through them. Altocumulus puffs or patches look "slow" (any rectangular orientation of cloudlets tends to correlate with slowness). When the wind is strong the altocumulus puffs will tend to line up in billows, perpendicular to the wind.

The middle clouds are primarily water clouds, but in some cases thin virga (snow trails) will fall out of them or snow will stream back from an altocumulus lenticular. Cirrus clouds are ice; cirrocumulus originate as water and may become ice quickly.

Figure 18. Fair weather cumulus.

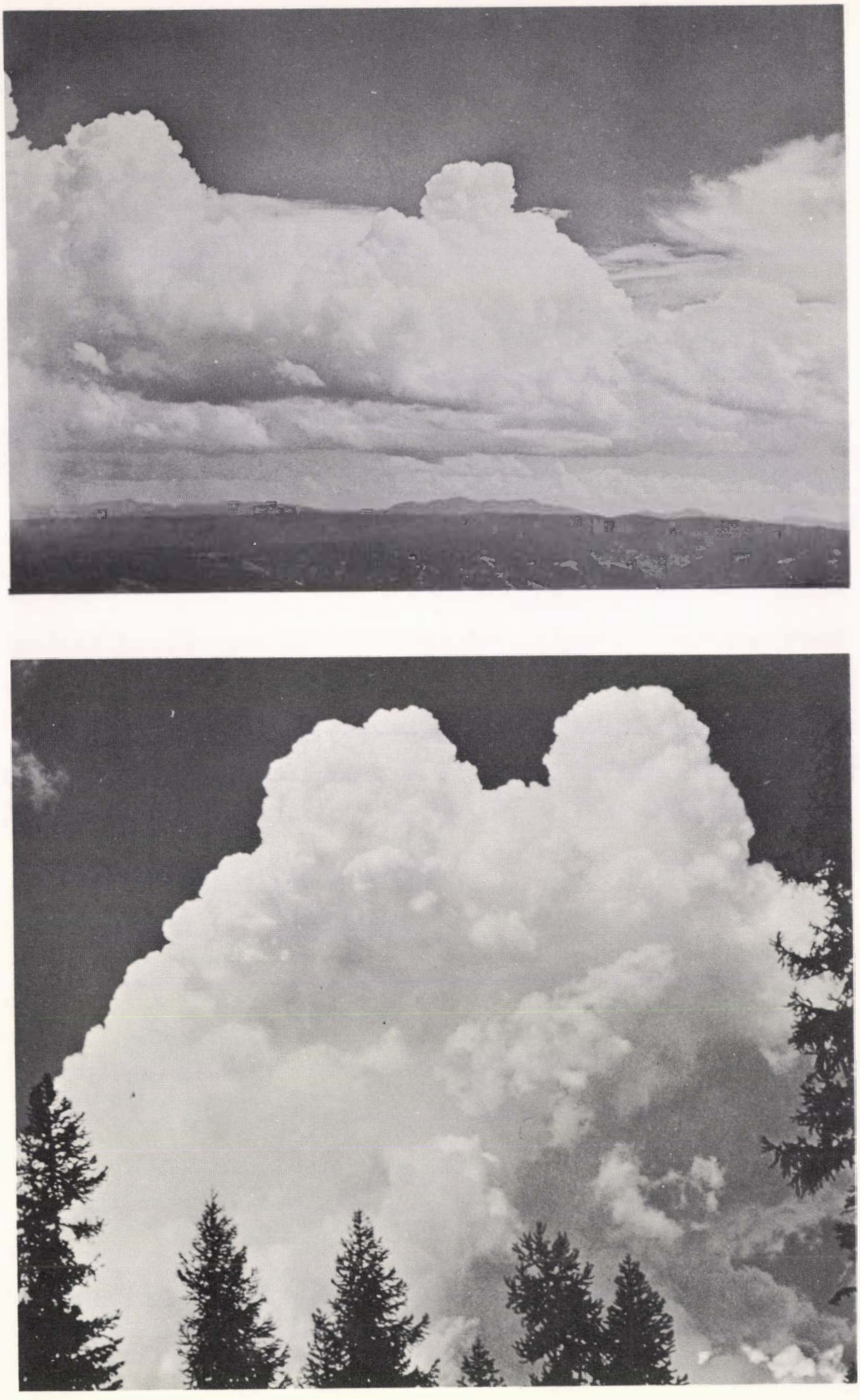


Figure 19. Towering cumulus.

Figure 20. Ice-topped cumulus.

Figure 21. Virga.

Figure 22. Rain.

Figure 23. Thunderstorm.

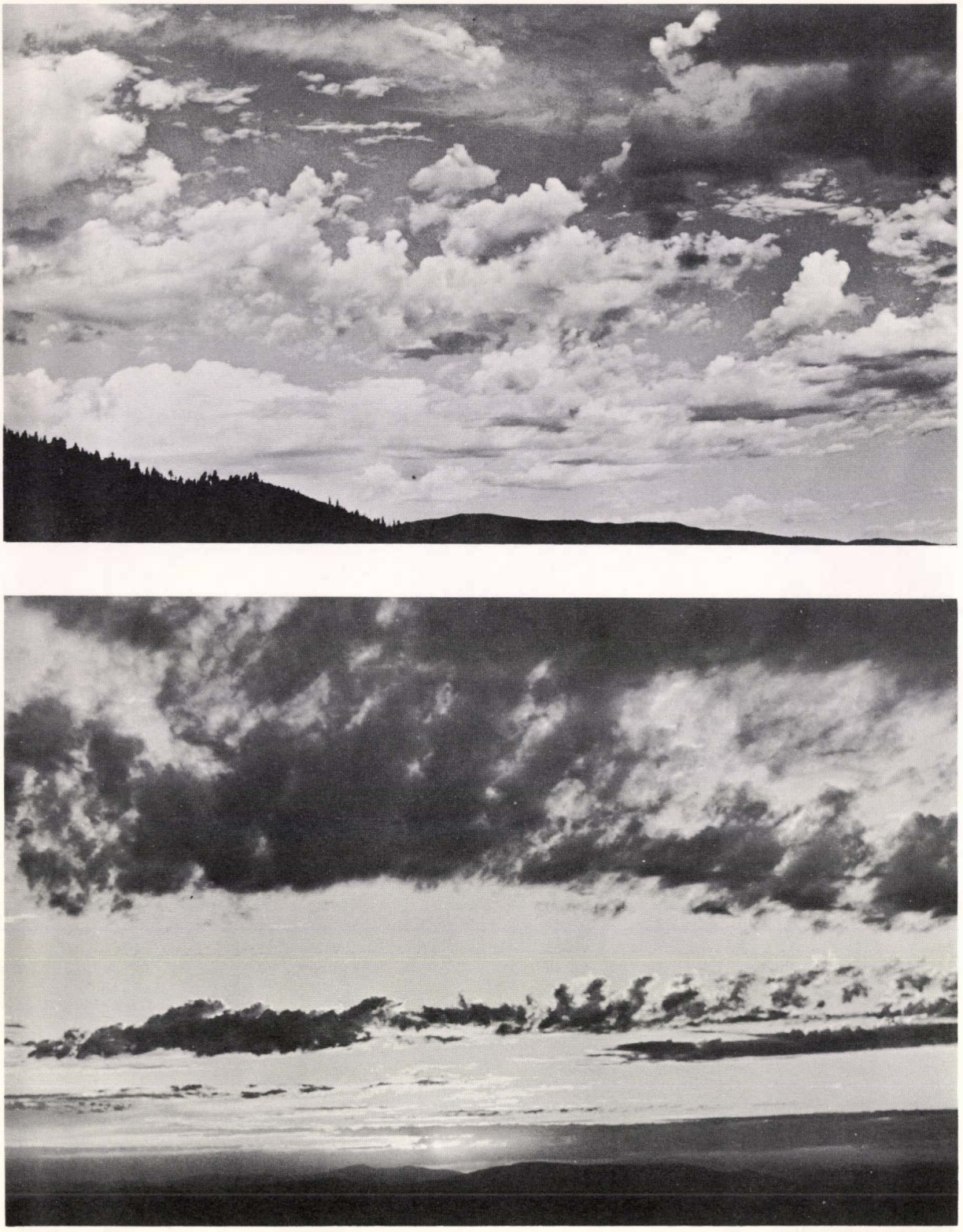


Figure 24. Altocumulus castellatus.

Figure 25. Altocumulus lenticular.

Figure 26. Altocumulus.

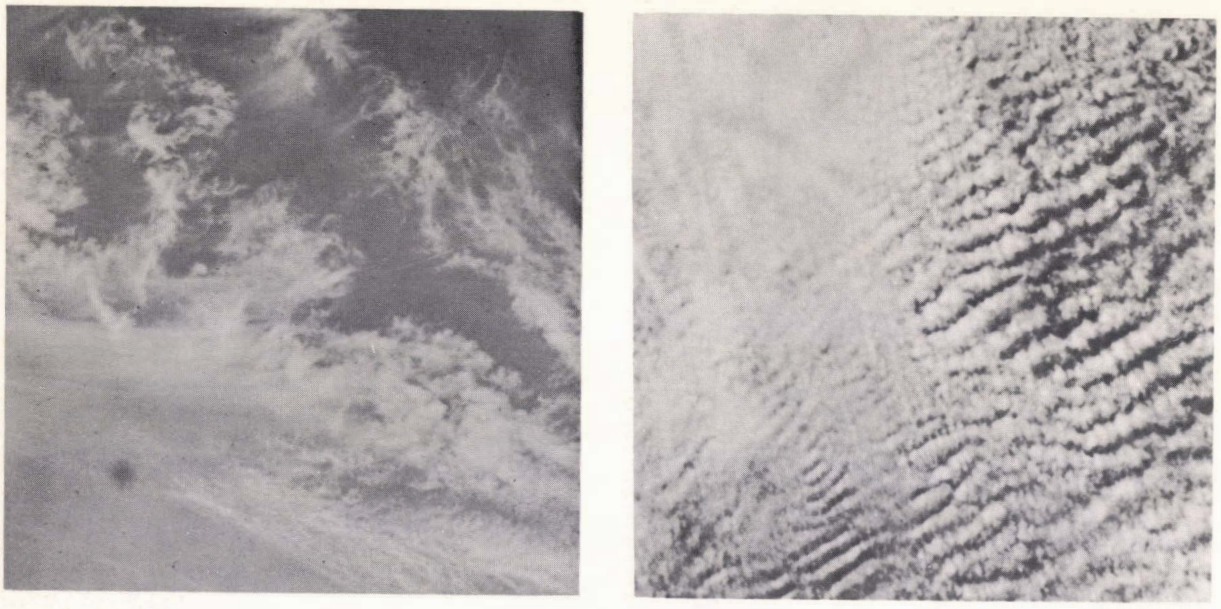


Figure 27. Cirrocumulus.

Figure 28. Cirrus.

FIRE-WEATHER FORECASTS

One of the special services provided by the U. S. Weather Bureau is fire-weather forecasting. The United States is divided into nine districts with a fire-weather forecaster in charge of each district.

During the fire season forecasts are sent to all protection agencies within the fire-weather district once or twice a day. The forecasts are transmitted by radio, telegraph, and telephone, depending upon available facilities.

Upon request, special or spot forecasts are made to aid in the control of forest fires and to assist in the management of prescribed burning operations. Under severe conditions a well-equipped mobile weather truck may be brought near the center of fire activity in order to provide more detailed localized forecasts.

Fire-weather forecasts are used in conjunction with the Model 8 Burning Index Meter. Predicted factors affecting fire behavior are converted into an estimated burning index for tomorrow. By using tomorrow's weather forecast in fire-control planning the probable behavior of going or potential fires can be foretold more accurately.

Fire protection agencies need fire-weather forecasts. The forecaster, in turn needs reliable weather measurements. Therefore, accurate well-maintained instruments, and adequately trained observers are essential for all parts of the system to function properly.

IV. FIRE WEATHER INSTRUMENTS--CARE AND REPAIR

A great deal of reliance is placed on fire-weather measurements and on fire-danger rating for successful administration of fire-control activities. Accurate, well maintained instruments are absolutely essential for the system to function properly. Nothing can be depended upon if basic equipment is faulty. Become thoroughly familiar with instructions for maintenance or repair of an instrument BEFORE any work is done on it.

ANEMOMETERS

Clean and oil each anemometer before instrument is placed in operation for the summer. Oil monthly during the fire season. Maintenance and minor repair procedure for the various types of anemometers is as follows.

Stewart Anemometer

Refer to figure 29. Remove the cover plate. Protect the gasket.

Remove screw on the top of the cup assembly hub. Put 2 drops of oil down the screw hole. If there is no screw, remove the cup assembly. Some cup assemblies slip on the shaft and are held by a set screw in the side of the hub. Others screw on, and may be held by a set screw. If cup assembly does not slip off after removing the set screw, hold the shaft and unscrew it.

If the gears, etc., are dirty or gummy, flush the entire housing out with cleaning fluid or gasoline (OBSERVE SAFETY PRECAUTIONS). Work shaft around and up and down. Let drain and dry.

Put 2 drops of anemometer oil on the lower shaft so they will go down to the lower thrust bearing.

Put 2 drops on the gears.

Put 2 drops at the top of the shaft (through the hole in the top of the hub if present) to oil the upper bushing.

Replace cup assembly. Spin slowly, check for friction or binding.

Adjust the spring contact so that it is just barely moved by the pin on the ring gear. If too tight, the anemometer will not turn past it at low air speeds; if too loose, the buzzer or flasher won't work properly.

DO NOT remove the ring gear or loosen the brass bearing blocks at the shaft ends. Tiny ball bearings will fall out and are extremely difficult to replace.

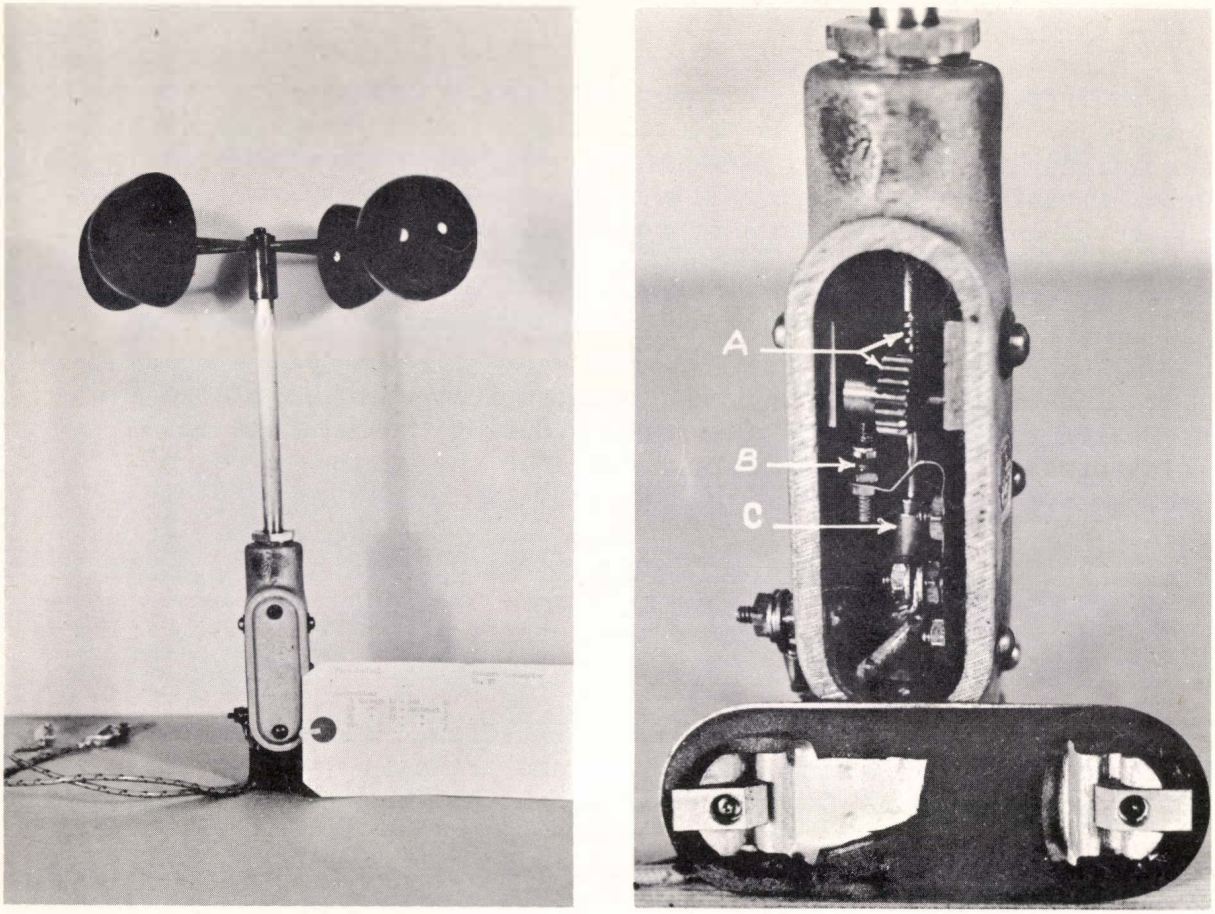


Figure 29. Stewart anemometer: Left, general view; Right, interior view. A, gears; B, contact points; C, lower thrust bearing.

Replace the cover plate. If the gasket resembles the one in figure 29, put the cut out portion up so the ring gear will not bind on it.

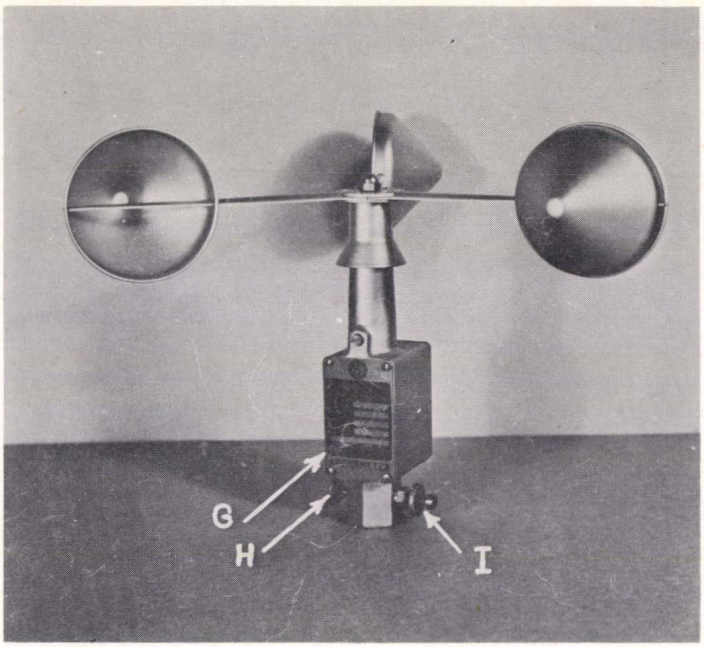
Friez "SA" (Small Airways) Anemometer

Refer to figure 30. Remove rotor retaining nut, lift off rotor and rain shield.

Keep dirt away.

Remove the 4 front cover screws and cover plate.

If dirty and gummy, flush out with cleaning fluid or gasoline and allow to dry thoroughly. OBSERVE SAFETY PRECAUTIONS.



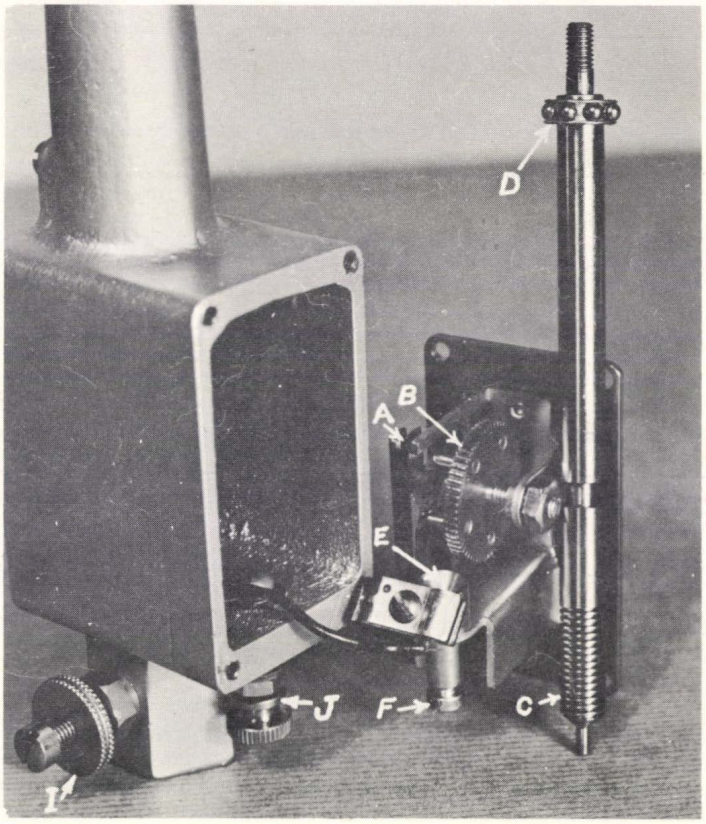


Figure 30. Friez "SA" (Small Airways) Anemometer. Upper, general view; Lower, interior view. A, contact points; B, worm wheel; C, worm gear, D, upper ball bearing; E, lower spindle bearing; F, lower bearing adjustment screw; G, remove plate to oil, H, thumb clamp screw; I, grounded terminal; J, insulated terminal.

Apply 1 drop of anemometer oil at each of the following places:

Each end of the worm wheel shaft

Top of gear on spindle

Lower end of spindle

Lower bearing

Upper ball bearing

Clean contact points by pulling a piece of paper or cloth between them; then check to make sure that positive, but not too hard, contact is made when a worm wheel pin closes the points.

Spin shaft to be sure it turns easily. If it does not coast freely, turn lower bearing adjustment screw (figure 30, F). Reach it with a screwdriver through bottom of instrument. By this means raise or lower shaft just enough to get longest spin.

Replace cover; tighten screws firmly, but take heed not to strip threads.

Replace rain shield, rotor assembly, and retaining nut.

Spin by hand again to make certain it is properly assembled.

Connect the wires to the 2 terminals (figure 30, I, J). Some older models have no grounded terminal; on these instruments, fray the wire and slip it up under the anemometer base when it is being mounted onto the bracket.

This instrument is constructed so that adjustment outside of a repair shop is rarely necessary. It is a precision instrument and is to be handled as such.

Firez "S" (Large Dial Recording) Anemometer

This instrument (figure 31) needs little attention other than oiling.

Oiling.--At the beginning of the season only: Remove dial cover by taking out the 2 screws on each side at the back. Put 1 drop of oil on each gear wheel (figure 32, I).

Monthly: Remove plug in side opposite the dial (figure 32, C). Put 1 drop of oil at the top of the worm gear on the spindle. Put 1 drop of oil at the lower end of the spindle where it enters the lower

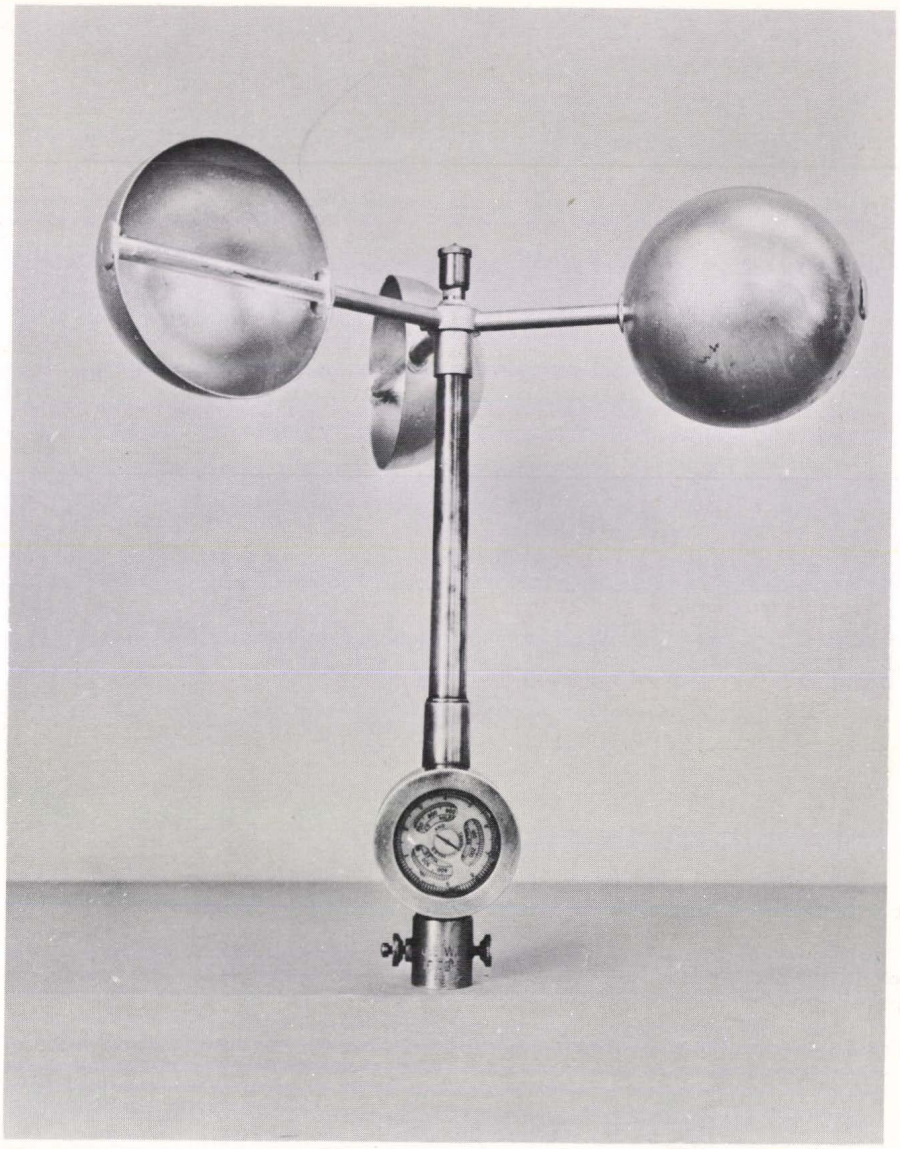


Figure 31. A Friez "S" type, dial recording anemometer.

bearing. Unscrew cover from oil cup on top of rotors. Fill about half full with oil. If there is no wicking running up from the oil and then down the center pipe, put one in using heavy cotton sewing thread.

Wiring.--See figure 32. Connect terminals B and E for buzzer operation. Connect terminals A and E for recorder operation.

Contacts.--If either the 1/60-mile buzzer contact (figure 32, F) or the mile contact (figure 32, H) does not work, remove the dial cover and clean the contacts. Use a point file, fingernail file, very fine

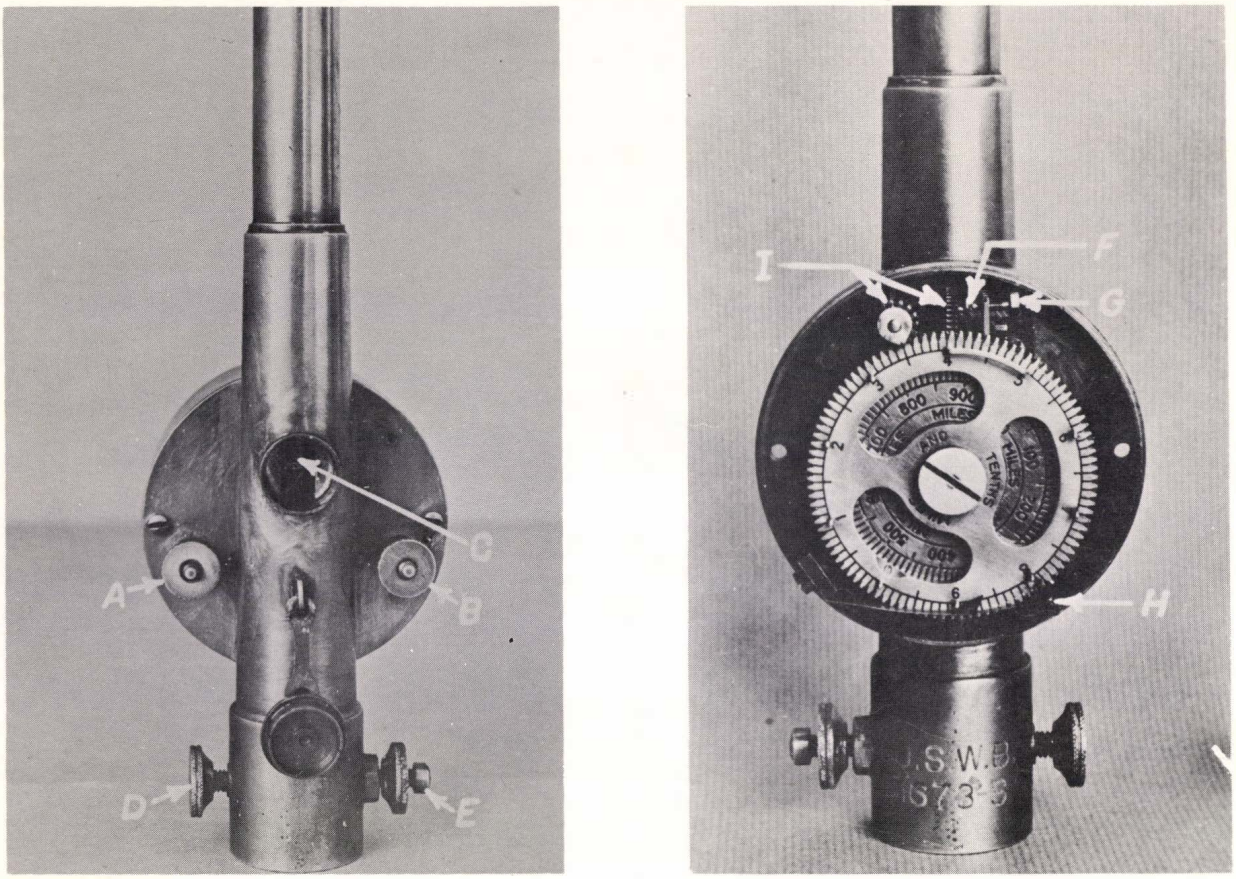


Figure 32. Dial of Friez "S" anemometer; back and front views. A, mile contact terminal; B, buzzer terminal; C, oil point; D, thumb clamp screw; E, grounded terminal; F, 1/60-mile contact (Buzzer); G, contact adjustment screw; H, 1-mile contact (recorder); I, gears (2).

emery, or hard finish paper. If the buzzer contacts do not open enough, increase the clearance by turning the contact adjustment screw (figure 32, G) to the left. If they do not close, turn screw to the right. If the mile contacts do not open enough, loosen the screw that holds the lower portion of the contact and drop the contact down slightly. If they do not close, lift the contact up slightly. It is occasionally necessary to bend the spring section of each of these contacts to secure proper opening and closing. Do this as a last resort.

Buzzer for Recording Velocity

Several difficulties may cause buzzer failure or intermittent operation. Refer to figure 33.

Buzzer does not operate.--Check the following things successively until the trouble is located.

Check batteries. 2 to 4 dry cells are enough; the number depends

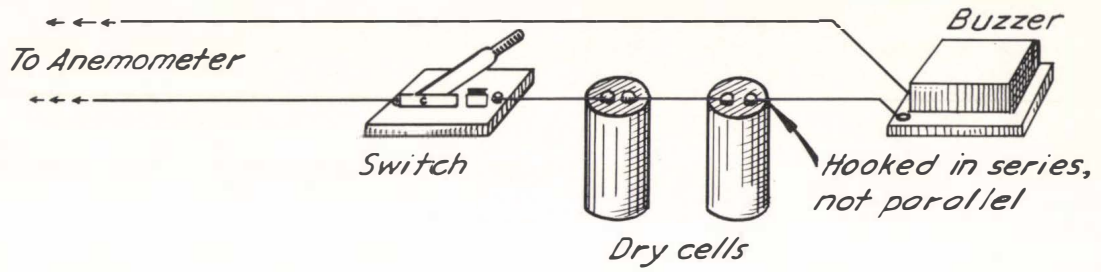


Figure 33. Wiring diagram for a buzzer.

on the line distance, buzzer voltage, and battery strength. Too much current will burn the buzzer contacts.

Check connections inside the buzzer. Most buzzer covers snap on and off.

Short across from switch to buzzer. If it does not work, clean the buzzer contacts. Use point file, fingernail file, or fine emery; finish by drawing a piece of rough paper between the contacts to remove dirt particles. If this fails, bend the vibrator closer to the magnet. If still no response, replace the buzzer.

Short across the terminals successively at the lightning arrester on the buzzer side. then on the anemometer side, and last, out at the anemometer stub wires.

If the buzzer has worked at all these places, then the trouble is in the anemometer or its stub wires.

Buzzer operates continuously with switch closed.--Check all circuits for shorts or bare wires.

PSYCHROMETER

Four variations of the wet and dry bulb type psychrometer are described. See figure 34.

U. S. Weather Bureau fan type--converted emery wheel fan--with 9-inch tubes.

Forest Service fan type with $9\frac{1}{2}$-inch tubes.

Standard sling type with $9\frac{1}{2}$-inch tubes.

Pocket psychrometer with $5\frac{1}{2}$-inch tubes and carrying case.

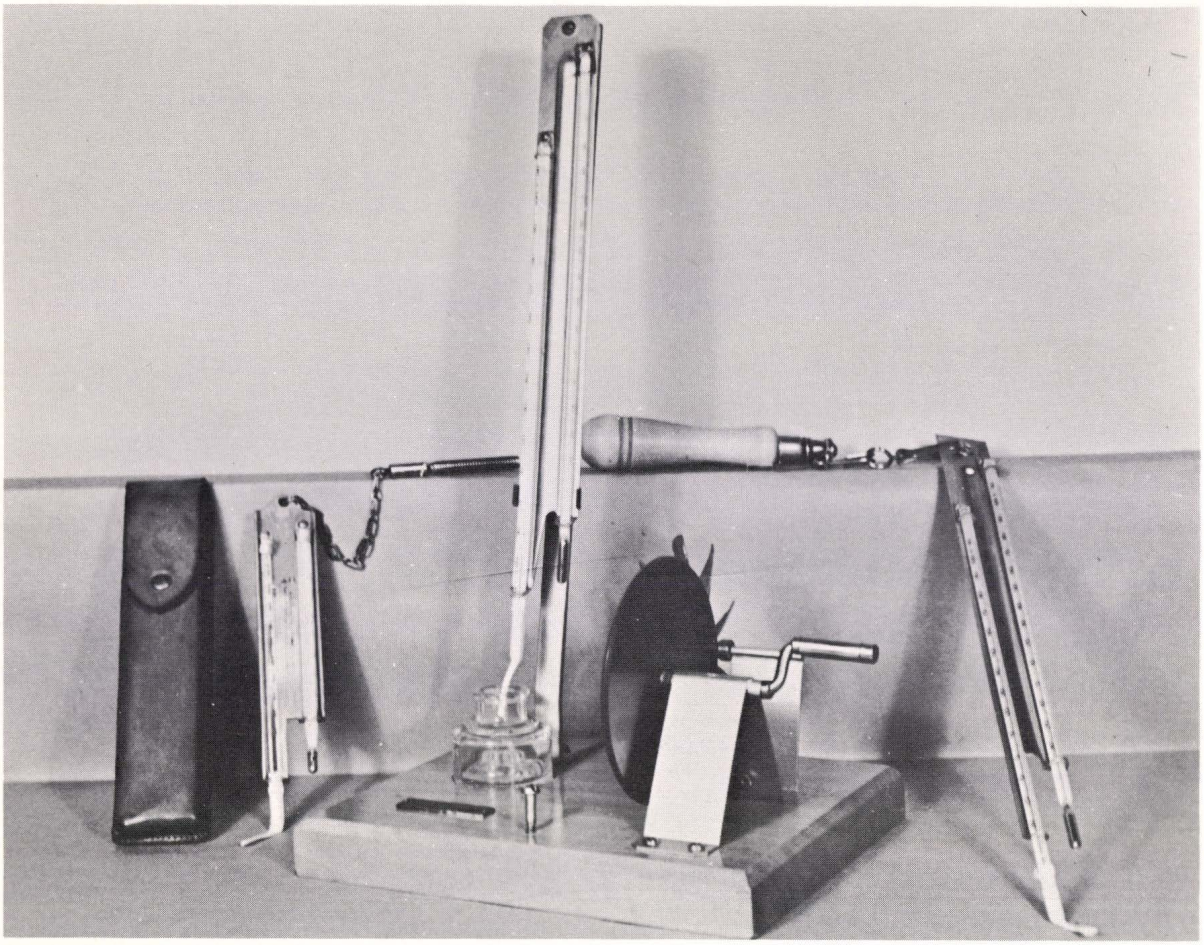


Figure 34. Psychrometers: pocket sling type, Forest Service fan type, standard sling type.

General

Keep the thermometer tubes clean.

Use fresh, mineral-free clean water.

Replace the wicking every 2 weeks, more frequently if in a dusty location or if the water leaves a mineral deposit.

Scrape deposit off the tube, or remove it with vinegar.

Place new wicking on the tube before cutting it; then cut it so 1 inch is left hanging below the tube to serve as a water reservoir. If an observer is out of wicking, the old wicking can be washed in soap and water, rinsed, and reused. 1 or 2 wraps of gauze bandage can also be used as a stop-gap measure.

U. S. Weather Bureau Fan Type

Mount solidly on the right hand side of the shelter near the bottom. Place the hook so that the dry bulb is 2 inches from the fan blades. See figure 35, lower photograph.

Lubricate the shaft lightly, so excess oil will not fly out.

Keep oil and dirt cleaned up currently.

Make periodic checks to keep all nuts tight; otherwise they may vibrate loose.

U. S. Forest Service Fan Type

Mount solidly in the instrument shelter. (See figure 35, upper photo.)

Oil the crankshaft lightly in the hole on top of the bearing.

The fan shaft can be oiled by springing its supporting strap steel away from the drive wheel and slipping the fan off.

If there is much slippage between the drive wheel and the hub of the fan shaft, increase the tension by tightening the tension screw or bending the fan support.

Standard Sling Type (9½-Inch Tubes)

Occasionally oil the shaft on the end of the handle.

Watch for excessive wear on the chain links, the swivel, and the connection between the hook and the thermometer frame.

Check frequently the screw on the end of the handle, as it often works loose.

Always store the psychrometer out of the direct sunlight, and in a clean location such as an instrument shelter or scale shelter.

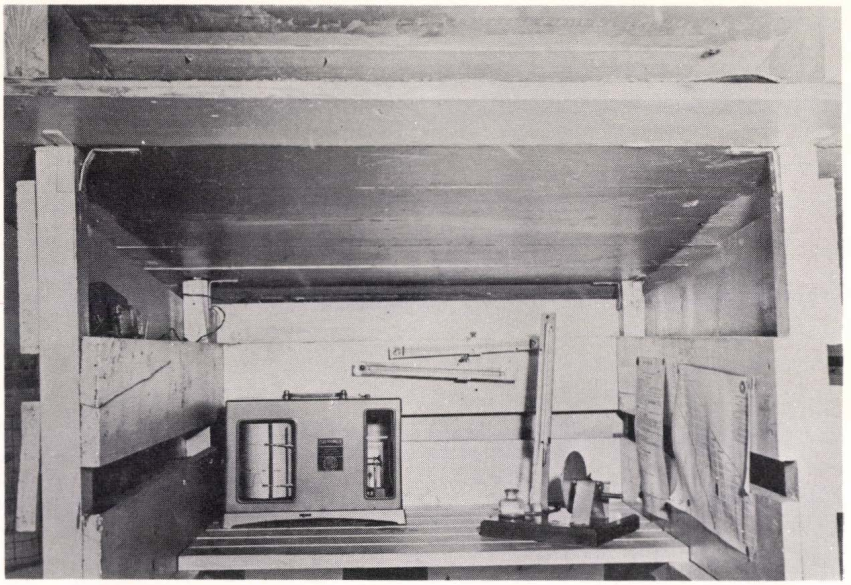
It is safer to hang it up than to lay it down.

Pocket Sling Type (5½-Inch Tubes)

Observe the same general rules as for the standard sling type.

Since the psychrometer is generally slipped into the case after each use, the wicking tends to become dirty more quickly than in the other types.

One word of caution: The chains and fastenings tend to wear out faster than on the standard type, so check these points often.



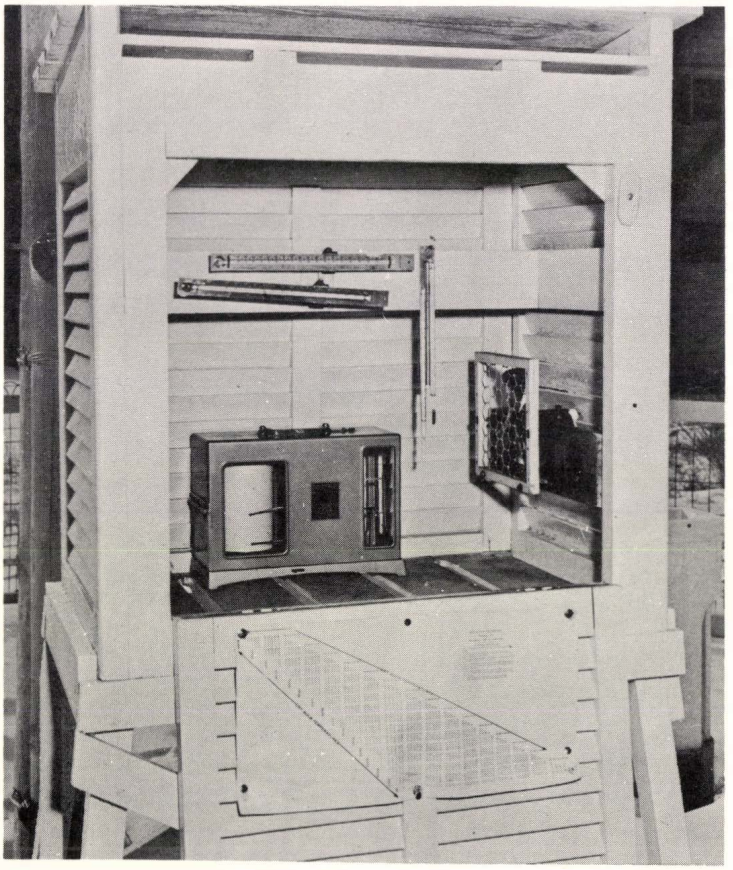


Figure 35. Instrument shelter interiors: Upper, Region 1 type; Lower, cotton region type.

FUEL-MOISTURE STICKS AND SCALES

Fuel-Moisture Sticks

Keep the sticks clean. Handle them with clean gloves, clean cloth, or paper.

Dust sticks frequently with a cloth or soft brush. Never try to remove dirt while the sticks are wet.

Avoid scraping them on the edge of the screen, etc.

Obtain new set of sticks if chips or breaks occur.

NEVER remove screw hook, regardless of type of scale used.

Lay sticks out under screen for at least 4 days before using to permit adjustment to the atmosphere.

Fuel-Moisture Scales, General

Three types of scales are used:

Triple-beam

Harvard balance

Appalachian and Region 6 type

Mount scales on a level, solid, clean platform. Keep scales dust free by a tight house and by dusting frequently. Treat scales with care since their sensitivity depends on sharp knife edges and unblemished quartz bearings. Never use oil on a scale.

Triple-Beam Scale

At the beginning of the season.--(Refer to figure 36.)

Dust thoroughly, especially the top of the pan.

Remove the bearing covers and bearing plates. (Figure 36, B.)

With toothbrush or rag clean the knife edges and bearings. Without removing the pan, clean the pan knife edges and bearings with a brush. Replace the bearing plates so that the smoother side is toward the knife edges. (Figure 36, B.)

Take care not to chip the bearings or dull the knife edges. Do not attempt to sharpen a knife edge. That is a repair shop job.

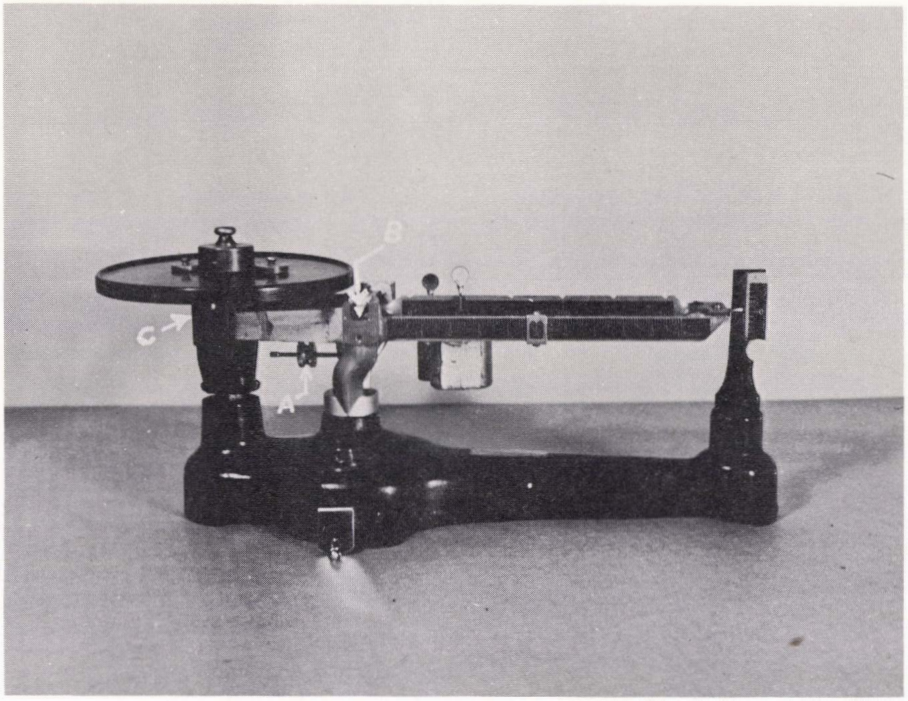


Figure 36. Triple-beam scale. The main bearing cover and bearing plate are removed and are standing against the base. A, knurled adjusting knobs; B, main bearing and knife edges; C, pan bearing and knife edges.

Current maintenance.--The scale must balance. Place the scale on a clean, level platform in the exact spot where the sticks will be weighed. With an empty pan and all 3 weights at 0, the pointer should oscillate the same number of divisions above and below the center line, or 0, and eventually come to rest at 0. Especially with sluggish scales, observing the oscillations will render more accurate weighings than noting only the final resting spot. A further precaution for a sluggish scale is to tap on the main bearing covers as it comes to rest.

If the scale does not balance: Adjust the 2 knurled adjusting knobs (they act together as lock nuts); screw out if pointer is low, screw in if pointer is high. After adjustment is correct, lock the nuts tightly together, then recheck the pointer. (Figure 36, A.)

A scale in balance with no weight on the pan is not necessarily accurate when 100 grams are weighed. For this reason, immediately before weighing the fuel sticks balance the scales by using a 100.0 gram test weight. Then any inaccuracies in the scale will be negligible within the range that the sticks weigh.

Shipping instructions.--Prepare the scales for shipping whenever they are to be moved any distance. Refer to figure 37. The pan needs to be removed if mailed or expressed, but not if it is to be carried in a vehicle. The remainder of the instructions hold for any type of transportation, including packing to and from a lookout.

Separate knife edges from bearings by securing pan end of beam up high and pointer end of beam down low. (Figure 37, A, B, and D.) With pan on, shipping clip alone will hold pan end up.

Tie weights securely to indicator post. (Figure 37, C.)

Put tape over pan bearings so they won't fall out and become lost. (Figure 37, E.) Place pan retaining screws in pan for safekeeping. Secure the thin blue metal bearing plates either in place or tape them onto pan.

Wrap pan in corrugated cardboard before placing it in a container.

Tie on adequate label to instrument, as in figure 37, F.

Never ship scales during the Christmas rush; breakage is increased considerably.

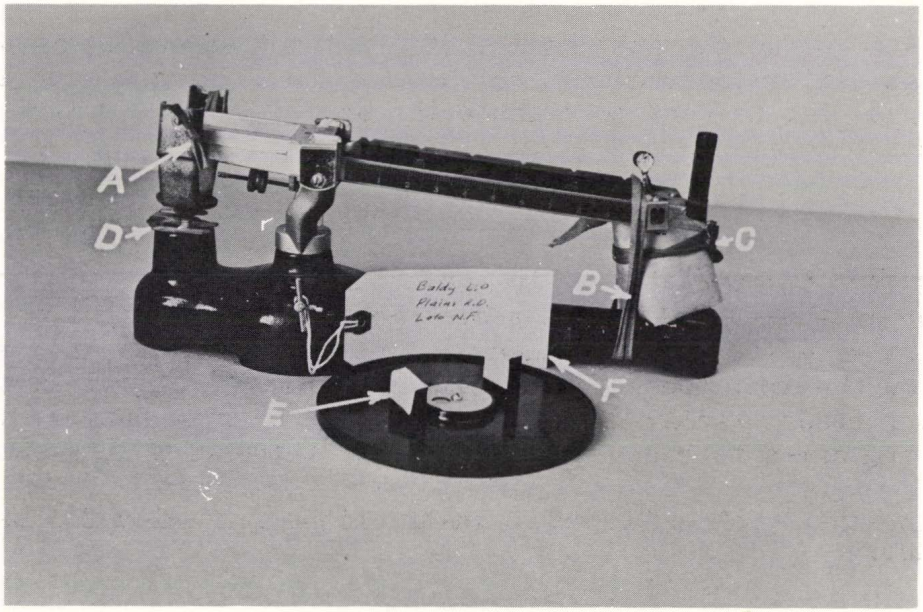


Figure 37. Scale prepared for shipment: A, beam tied up; B, beam tied down; C, weights tied; D, shipping clip in place, E, tape over pan bearing; F, well labeled.

In packing into a box, a few well placed pieces of corrugated cardboard are far more effective than stuffing the box with crumpled newspapers. Papier-mache egg container type of material works well.

Harvard Balance Scales

The general principle is the same as for the triple-beam type, except that separate weights are placed on the right hand pan instead of being placed in notches along the beams. Follow the triple-beam scale instructions as much as possible. The knurled adjusting knobs for balancing the scales are shown in figure 38, A. The main bearings with the cover plates removed are shown in figure 38, B.

Appalachian Scale

This type of scale reads moisture percent directly on an arc, marked off from 0 to 50 percent. Refer to figure 39.

Scale must be mounted solidly and squarely in 2 planes.

The wire hook holding the 100.0 gram check weight must swing freely.

The axis pin in the main bearing must be straight, and the bearing holes free from dirt or grease. The arm must swing free in its bearing and not rub on the arc.

The sliding weight must be movable, but not so easily as to slip out of place after the scale is balanced. The sliding weight and the check weight must be used to balance the scale; the 100.0 mark on the arm may not be quite exact.

Region 6 Scale

This type is very similar to the Appalachian scale. The main difference is that the Region 6 scale has no sliding weight on the arm. To balance it, hang the check weight on the wire at the extreme left end of the arm; loosen the 3 wing nuts; move the plate until the pointer reads exactly zero. Tap the main bearing hub to make sure the arm comes to rest accurately. Reset the wing nuts securely.

Follow the Appalachian scale instructions generally for use and maintenance.

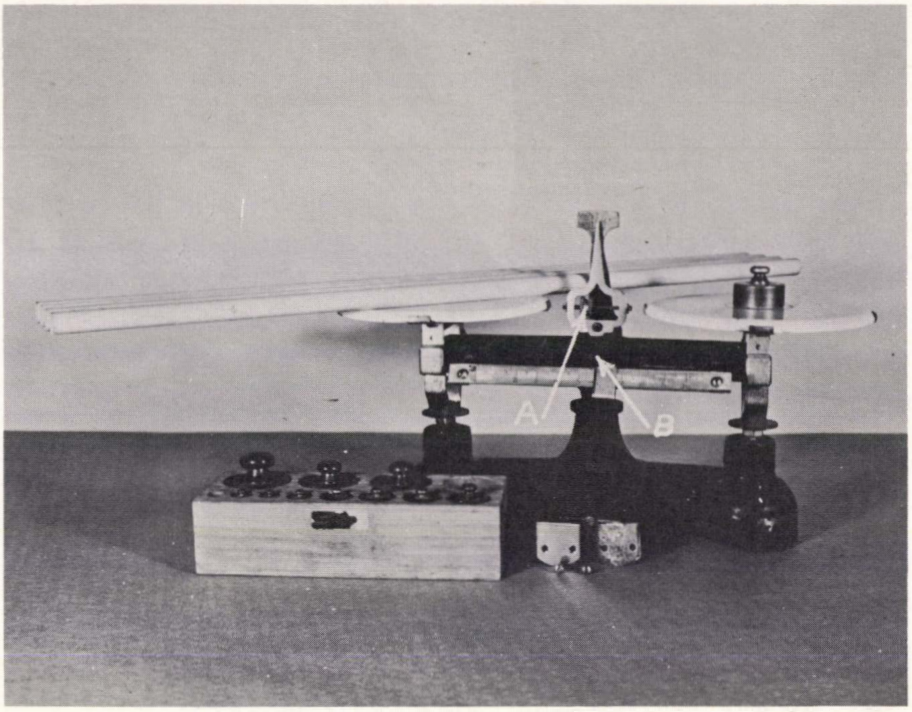


Figure 38. Harvard balance. Main bearing cover and bearing plate are removed: A, knurled adjusting knobs; B, main bearing.

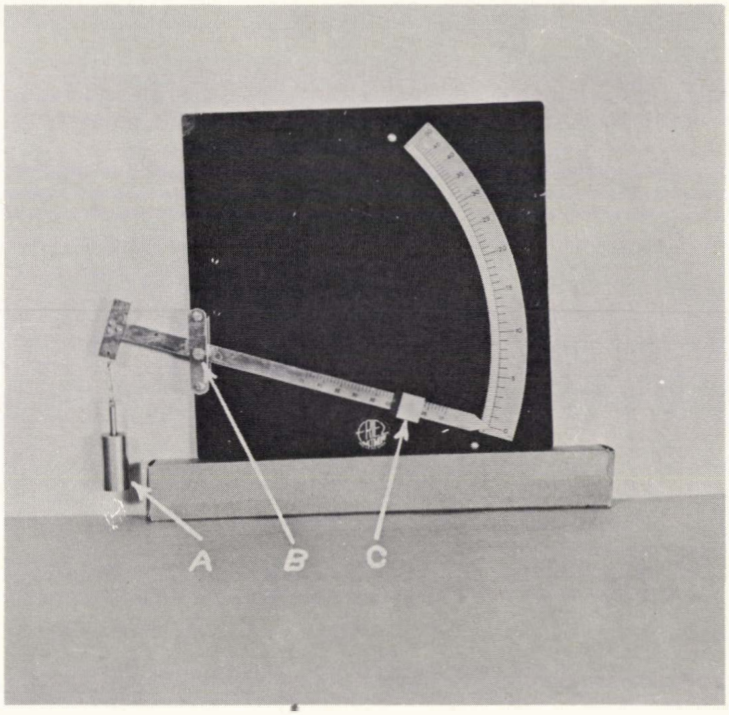


Figure 39. An Appalachian scale: A, check weight; B, main bearing; C, sliding weight.

RAIN GAGE

Two types are in common use: The U. S. Weather Bureau type which holds 2.00 inches of water in the measuring tube, and the U. S. Forest Service type which holds only 0.50 inch. Their maintenance is the same. See figure 40.

Keep top of funnel level.

Keep inside of both the measuring tube and overflow can clean.

Test periodically for leaks.

Remove funnel and measuring tube during freezing weather.

Do not touch the lower part of the measuring stick with fingers or permit the stick to become oily or dirty; this makes it more difficult to measure the height of the water level.

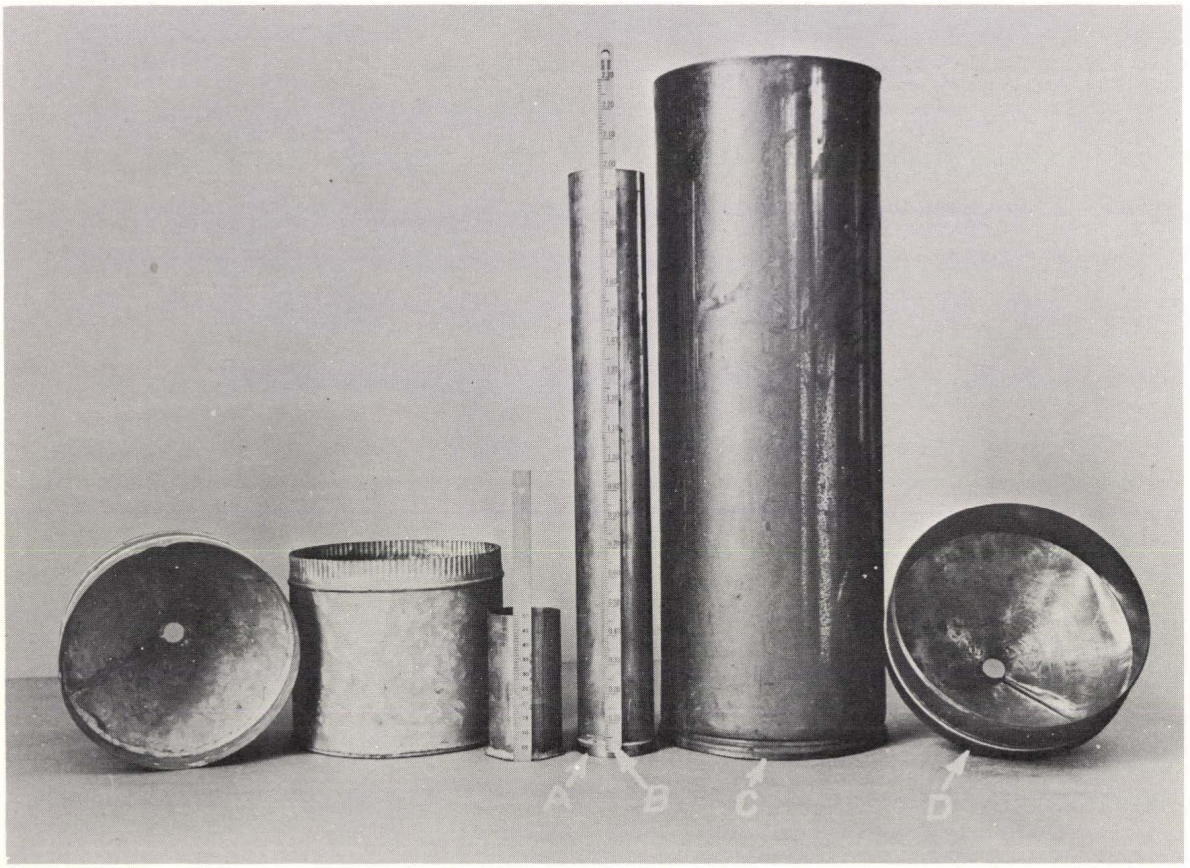


Figure 40. Rain gages, disassembled: A, measuring tube; B, measuring stick; C, overflow can; D, funnel.

Expose all thermometers in constant shade, but in free moving air. An instrument shelter is preferred; errors will result if mounted near a door or window. See figure 41. Also, figure 35 shows maximum-minimum thermometers mounted in instrument shelters.

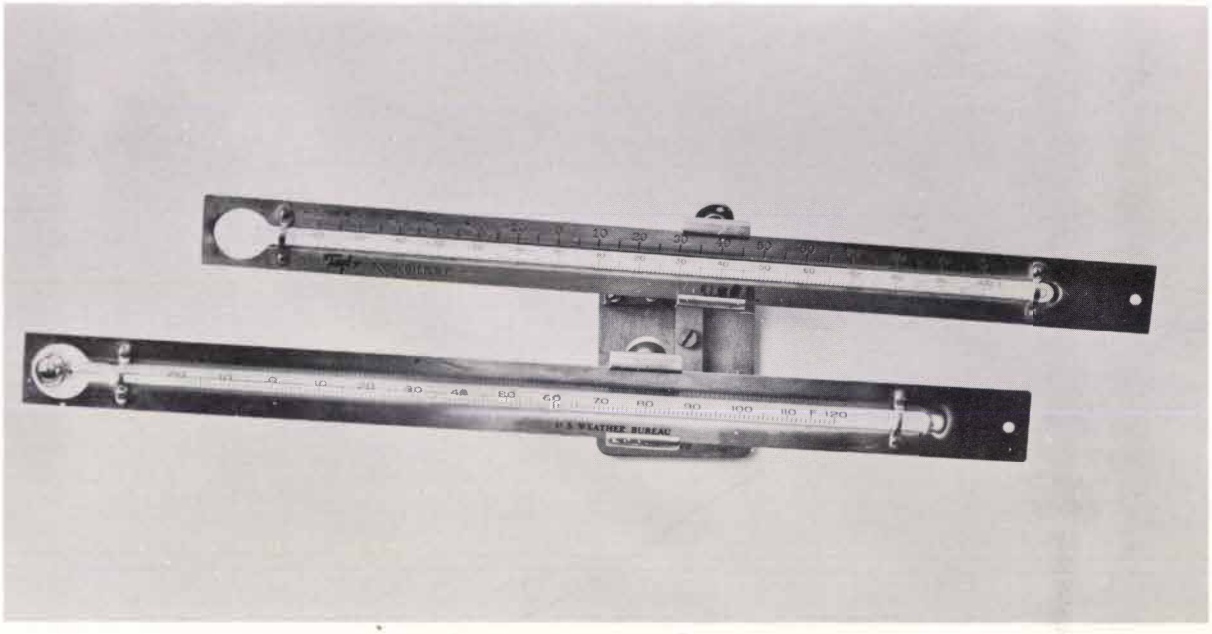


Figure 41. Maximum and minimum thermometer mounted in bracket.

Maximum Thermometer

The maximum thermometer is similar to a clinical thermometer, filled with mercury. There is a constriction in the capillary (the fine bore of the tube) just above the bulb. As the mercury in the bulb expands with heat, it is forced through the constriction. Upon cooling, the mercury above the constriction will not run back into the bulb unless forced back by whirling or shaking. Since the mercury column is calibrated from the constriction, the thermometer must be vertical to indicate the maximum temperature recorded since it was last set. The mercury is free to float above the constriction; for this reason the thermometer is often erroneously thought to be defective.

If the thermometer is whirled with the mercury not down against the constriction, the force of whirling may fracture the constriction, as shown in figure 42. Replace such a thermometer. It is known as a "retreater," as the mercury will retreat into the bulb and thus will not record the proper maximum temperature.

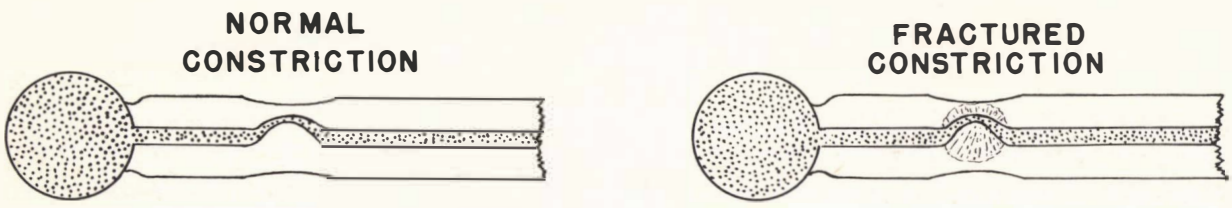


Figure 42. Normal and fractured maximum thermometers.

Mount the maximum thermometer near the 80° mark. If mounted too near the middle, the mercury will tend to split when whirled; part of it is liable to become permanently lodged in the top of the bore. Follow the procedure described under the minimum thermometer when attempting to bring the mercury column back together.

Tighten set screw securely to prevent thermometer from being thrown out when whirled. When properly mounted, bulb end is raised about 5° above horizontal.

Minimum Thermometer

The minimum thermometer, filled with alcohol, has a small glass index rod in the bore. This index is free to float in the alcohol. The thermometer is mounted with the bulb end about 5° below the horizontal. When the alcohol contracts, due to cooling, the alcohol retreats down the bore. The surface tension of the top of the alcohol column is great enough to drag the index toward the bulb while retreating. When the alcohol again expands, due to heating, the index is left behind. The minimum temperature for a given period is determined by reading the right hand end of the index (the end away from the bulb).

Frequently, the alcohol vapor condenses in the upper part of the bore, showing up as separations in the alcohol column as in figure 43. It is difficult to observe any alcohol that is lodged at the extreme top of the thermometer. Check for a separated column if the maximum and minimum, after settling, do not agree within plus or minus 1°. The separations can generally be removed by one of the following procedures.

Hold in hand, bulb end away. Shake down with a rather long sweep, ending abruptly.

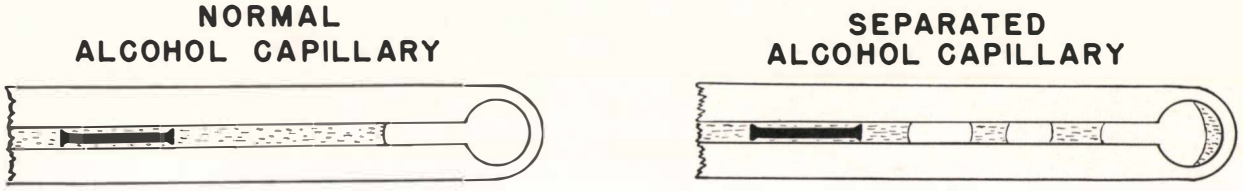


Figure 43. Normal and split column minimum thermometer.

Sling it by attaching it to a psychrometer handle to which is attached about 1½ feet of chain or wire. This is the quickest and easiest method.

Lay out several thicknesses of blotter paper, a book, or similar object with some "give." With the bulb end down, tap the thermometer lightly. The detached drops will gradually unite with the main column. Do not tap too hard, or the nub at the upper end may break and ruin the tube. After the liquid has been rejoined, let the thermometer stand vertically in a warm place for an hour to help any tiny remaining droplets to drain down the main column. Warming to about 100° F. before starting may assist the process.

Do the following only as a last resort: Slowly heat the alcohol, running the separations all into the very small bulb at the top of the bore. Just as the last separation has been ejected from the bore, remove the heat source and allow to cool while hung in a vertical position. This will cuase all the alcohol molecules to reunite with the parent solution. CAUTION: The application of heat in this method must be very carefully applied or the expanding alcohol will blow the top off the bore.

Maximum-Minimum Bracket

Refer to figure 44. Oil spinning shaft periodically through small oil hole.

Clean thoroughly at least once a year.

Remove the maximum thermometer.

Take screw out of center of shaft.

Slide spinner off and clean out with cleaning fluid.

Clean oil hole.

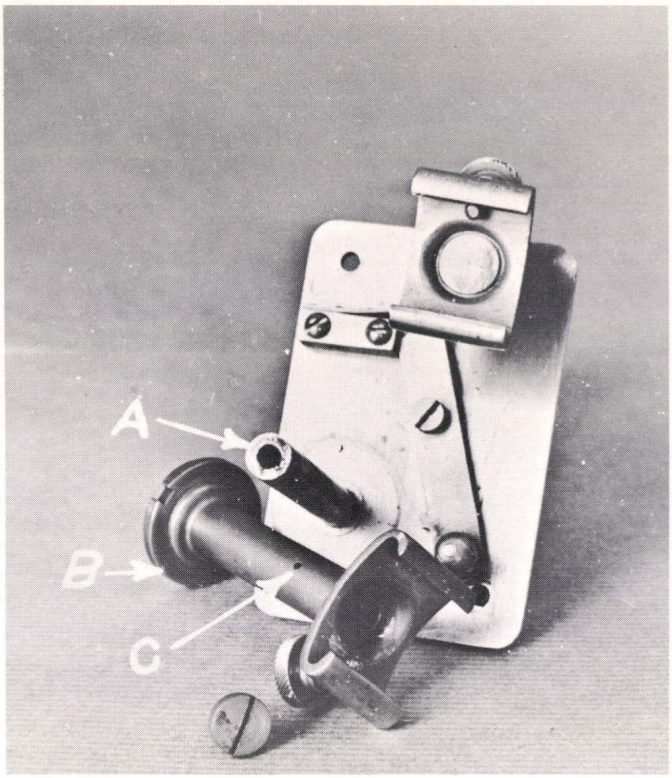


Figure 44. Maximum-minimum bracket: A, shaft; B, spinner, C, oil hole.

Oil and replace parts.

Set maximum thermometer in its clamp at about the 80° mark. Center minimum thermometer in its clamp. Place bulb of both thermometers toward the left. Mount bracket, minimum support on top, in a place where the spinning maximum thermometer will not strike anything, such as the hygrothermograph. In the cotton region shelter this will be about the middle of the cross board. Refer back to figure 35.

HYGROTHERMOGRAPH

General

The hygrothermograph is a precise and delicate instrument; its cost is greater than all of the other instruments combined. House it in an instrument shelter. Keep it dust free with a small, soft brush; if the site is dusty, carefully brush the humidity hairs once a week. If extremely dusty, wash the hairs with clear water of air temperature, and a camel's hair brush. Do not touch the hairs with the hands as any oil or dirt film will spoil the accuracy of the humidity record. The levers, shafts, arms, springs, and hairs are all easily damaged if not handled with care.

Clock

Speed.--If clock gains or loses more than 15 minutes per day, adjust it.

Slide open the small cover on the top of clock.

Move pointer toward "S" if it is running fast, or toward "F" if it is running slow.

Do not over correct; check speed for the next week or two.

Often a bent spindle will cause a clock to stop or run erratically.

If clock cannot be adjusted or if it will not run, notify the Weather Bureau fire-weather forecaster.

Backlash.--Check clock backlash at the beginning of each season or whenever a new clock is installed. Turn clock lightly back and forth, with pens raised. The amount of play should cause an audible click between the gears, but not enough to cause more than one-half hour's backlash. Try this at several points around the clock.

The clock drive gear may mesh too tightly with the large stationary gear at the bottom of the spindle, causing the clock to stop or lose time. A test for such a case is to remove clock from spindle; if it then operates normally, the gears are meshing too tightly. A bent spindle can cause a backlash on one side of the clock and a drag on the other side. Ask for replacement of a bent spindle.

If there is a drag between gears:

Remove clock from spindle.

Loosen the 3 screws in the bottom of clock.

Move drive gear away from center of clock. A very slight movement will usually be sufficient.

Tighten the screws, replace clock on the spindle and test for amount of backlash.

Shipping.--Follow these instructions; the clock can be easily damaged if not prepared properly for shipment.

Remove both clock and spindle, complete with gear washers and wing nut from the chassis.

Wrap spindle and gears in paper and place them inside the top of the clock drum.

Wrap clock in paper or place it in a clean paper sack.

Pack in a box containing cushioning material, such as shredded paper.

Address box to the Weather Bureau fire-weather forecaster.

Tie securely with string, as well as taping, because boxes often receive rough treatment in transit.

Pens

Indication of time.--If both the humidity and the temperature pens do not indicate the same time on the chart, adjust one of them.

A pen is clamped onto the pen arm from the rear by means of little flaps; thus a pen can be moved in or out along the arm and the flaps recrimped against the arm; use pliers very carefully.

Cleaning.--If pen does not ink well, draw a piece of regular chart paper or sack paper through the points to clean out any dirt or congested ink.

Sharpening.--If pen makes too broad a trace, clean as above and wipe excess ink off the sides. If trace is still too broad, remove it from pen arm by simply pulling it off to the left; then use a point file or a fine mill file to sharpen points until light will not reflect off nibs. If too sharp, a pen will cut the paper. If difficulty is still encountered, order new points.

Temperature Pen Adjustment

Adjust if the temperature trace varies more than 2° from the dry bulb reading while the temperature is leveled off. Adjust either up or down by turning the knurled thumb screw connected to the crescent-shaped temperature element (figure 45, A). Do not adjust while the temperature is changing, as there is considerable lag in the reaction time of the temperature element. Make adjustments on the basis of the dry bulb temperature BEFORE the psychrometer is fanned or slung. Briefly lift the pen off the chart during adjustment to eliminate the effect of surface friction between the pen and the paper.

Humidity Pen Adjustment

Adjust if the humidity trace varies more than 3 or 4 percent from the psychrometric reading while the humidity is leveled off. Adjust humidity pen in the same manner as described for temperature pen. Use knurled thumb screw attached to the lower end of the humidity hair element (figure 45, C). Adjust humidity pen on the basis of an average of 3 psychrometric readings. Do not adjust while humidity is changing.

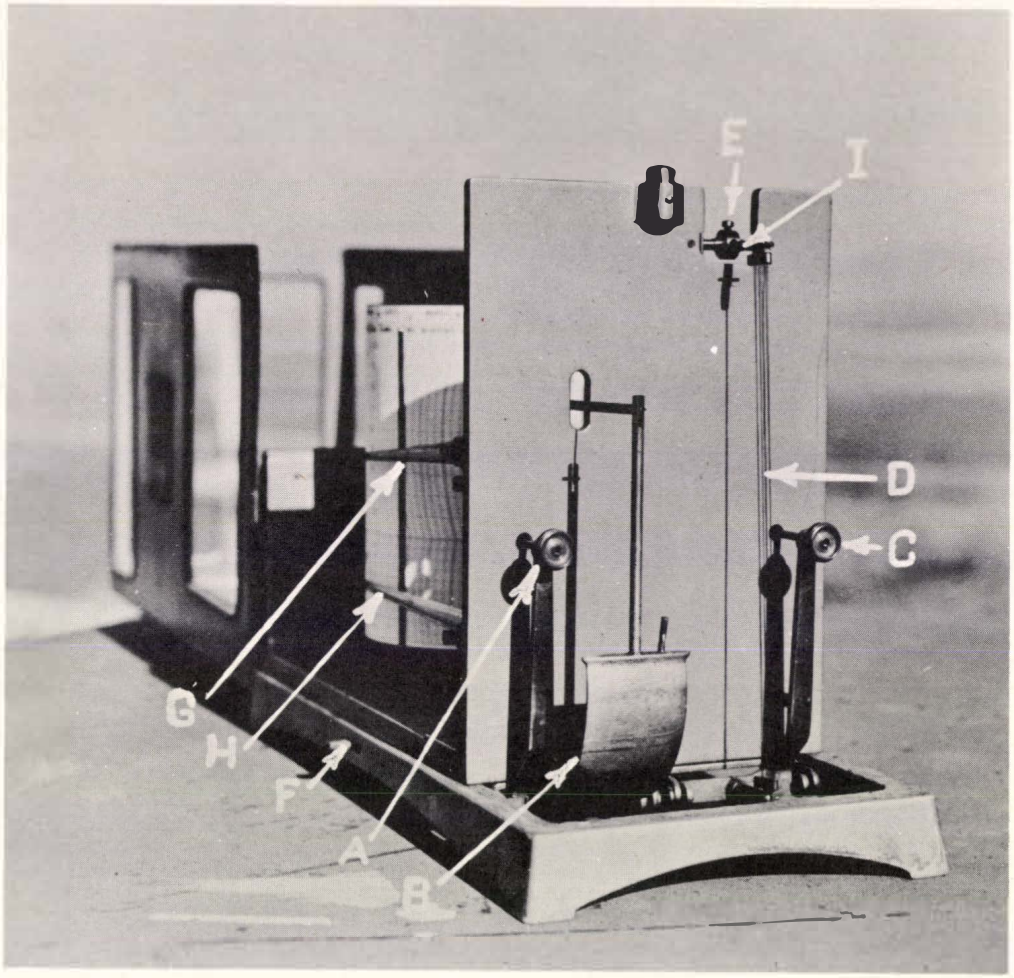


Figure 45. Hygrothermograph: A, temperature pen adjustment thumb screw; B, temperature element; C, humidity pen adjustment thumb screw; D, humidity element; E, swivel hub set screw; F, pen throw-out lever; G, temperature pen; H, humidity pen; I, magnification bar.

Temperature Spread Adjustment

Occasionally a hygrothermograph will not indicate correct temperatures at both the maximum and the minimum values. The spread may be too great or it may be too small. Do not attempt to adjust for this condition. Advise the Weather Bureau fire-weather forecaster.

Humidity Spread Adjustment

When in proper adjustment, the humidity pen will register the same as the lowest afternoon humidity obtained by a psychrometer; it will also rise to between 95 and 100 percent at night if fog or heavy dew is present.

Too great or too small a daily spread in a hygrothermograph humidity record is common. Field personnel can keep this part of the instrument in proper adjustment if the ensuing instructions are carefully followed.

For sake of illustration, assume the adjustment for low humidity is correct and saturated air is present at night. If the highest humidity on the chart is over 100 percent, the spread must be decreased. If the highest humidity on the chart is below 95 percent, the spread must be increased.

Make the humidity spread adjustment only at the time of day when the humidity pen on the chart has leveled off at its lowest value for an hour or more, preferable on a day when the humidity is below 30 percent.

Trial and error method.--Refer to figure 45. In the afternoon when relative humidity has leveled off, average 3 careful psychrometric readings and determine relative humidity.

Mark a pencil reference line on the magnification bar at the swivel hub. (Figure 45, E and I.)

Loosen swivel hub set screw that holds the magnification bar in place.

Move magnification bar out away from the clock to decrease the spread.

Move bar in toward the clock to increase the spread.

A movement of one-eighth inch will cause a change in spread of several percent.

Tighten the set screw firmly.

Adjust the pen with the thumb screw (figure 45, C) to correspond with the actual psychrometric humidity.

Often, several adjustments over a period of a week or two are required before the proper adjustment is obtained.

On one type of hygrothermograph the magnification bar is suspended at the right end instead of at its center. It is not adjustable, but the suspension slide that holds the hairs can be moved along the magnification bar. Move the suspension slide out away from the clock to increase the spread. Move the slide in toward the clock to decrease the spread. Note that the movement is opposite from that for the other hygrothermographs. Except for this difference, the instructions for the other type of instrument hold good for this one.

Hair-wetting method.--This is a more precise, time-consuming method. Good results can be obtained in about 2 hours; however, it should be followed up with the trial and error method. The wetting method is especially helpful after installing a new set of hairs.

Perform this method either outside on a warm, dry afternoon, or inside a warm, dry room.

Take 3 very careful psychrometric readings to determine the correct humidity; set the humidity pen accordingly.

Dip a soft camel's hair brush in clean water. Stroke the humidity hairs upward on both sides until they are immersed in a continuous stream of water. Hold the water container directly beneath the hairs. Continue until it is certain the hairs are completely saturated. Then stroke all the free water off the hairs, allowing them to spread apart.

Read the humidity on the chart at this instant. If the humidity pen is approximately 93 percent, do not change the adjustment.

If pen indicates over 95 percent, the spread is too great.

If pen indicates under 91 percent, the spread is too small.

It is characteristic for the hairs to indicate approximately 93 percent when saturated with water, but to indicate 100 percent when saturated with vapor (fog, dew).

If adjustment is necessary, follow instructions for moving the magnification bar as outlined in the trial and error method.

After magnification bar adjustment has been made, wet the hairs again.

Set humidity pen at 93 percent, using thumb screw adjustment.

Let instrument set for 15 to 30 minutes to permit humidity pen to return to its former low value and level off. Then set pen according to a new psychrometric humidity reading.

Continue to repeat the process until the pen when wet will indicate approximately 93 percent, and when dry will indicate the current low humidity as measured by the psychrometer.

Occasionally a set of hairs will indicate only 80 percent or so when wet with water, but 100 percent when wet with night fog or dew. If this occurs, order and install a new set of hairs. After 3 or 4 days' exposure, proceed with the adjustment process.

Storage

At the end of the fire season, store the hygrothermograph in an unheated room or leave it in the instrument shelter if there is no danger of pilfering or of collecting too much dirt. Protect it from rodents. Lift the pens off the drum and drain the ink by pressing them against a moist blotter; then clean the excess ink off so the pens will be ready for operation in the spring.

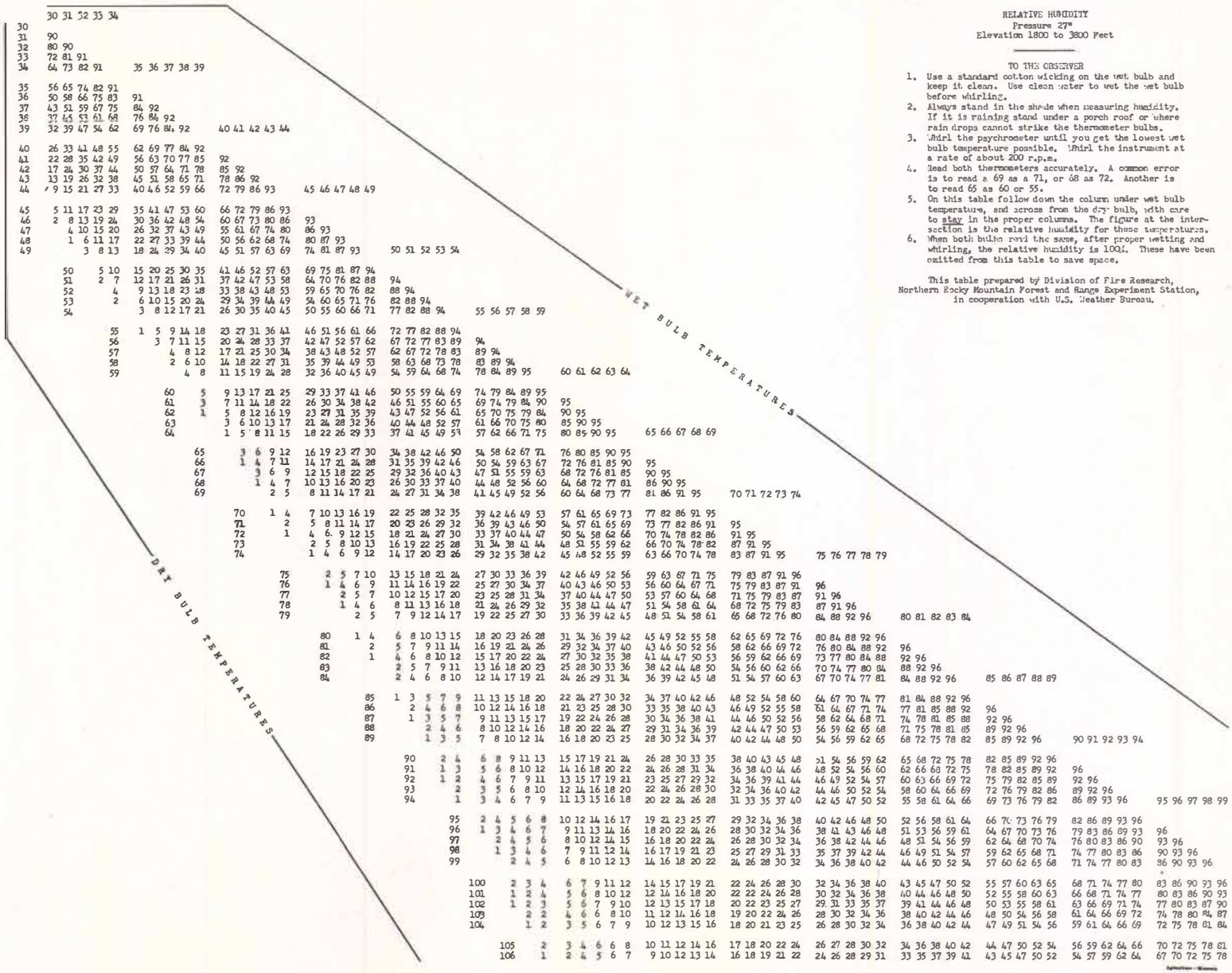
APPENDIX

Psychrometer Chart, 1,800-3,800 Feet Elevation

Psychrometer Chart, 3,800-6,000 Feet Elevation

Psychrometer Chart, Over 6,000 Feet Elevation

Fire-Danger Station Inspection--Self-Training Guide

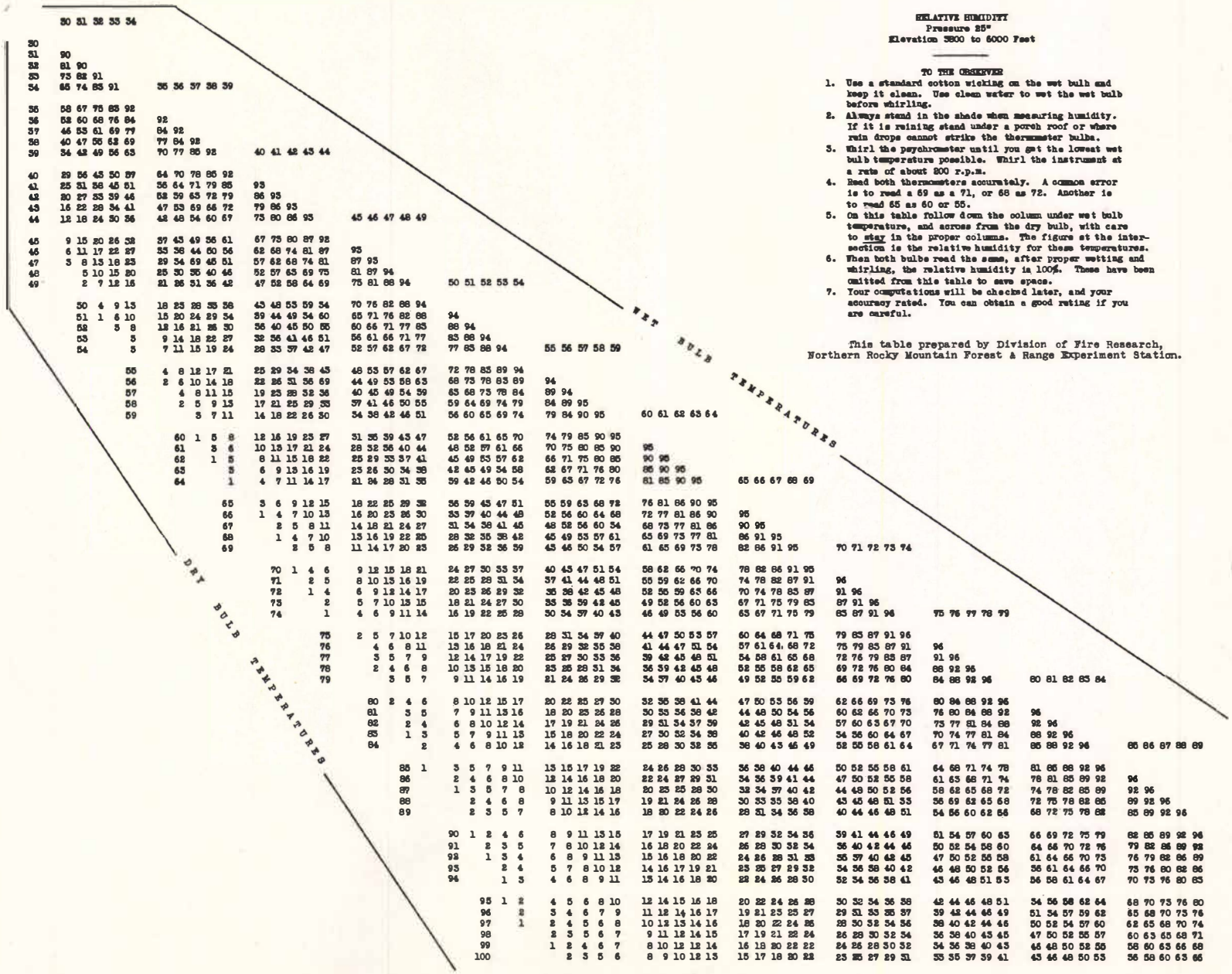


RELATIVE HUMIDITY
Pressure 27"
Elevation 1800 to 3800 Feet

TO THE OBSERVER

1. Use a standard cotton wicking on the wet bulb and keep it clean. Use clean water to wet the wet bulb before whirling.
2. Always stand in the shade when measuring humidity. If it is raining stand under a porch roof or where rain drops cannot strike the thermometer bulbs.
3. Whirl the psychrometer until you get the lowest wet bulb temperature possible. Whirl the instrument at a rate of about 200 r.p.m.
4. Read both thermometers accurately. A common error is to read a 69 as a 71, or 68 as 72. Another is to read 65 as 60 or 55.
5. On this table follow down the column under wet bulb temperature, and across from the dry bulb, with care to stay in the proper columns. The figure at the intersection is the relative humidity for those temperatures.
6. When both bulbs read the same, after proper wetting and whirling, the relative humidity is 100%. These have been omitted from this table to save space.

This table prepared by Division of Fire Research,
Northern Rocky Mountain Forest and Range Experiment Station,
in cooperation with U.S. Weather Bureau.

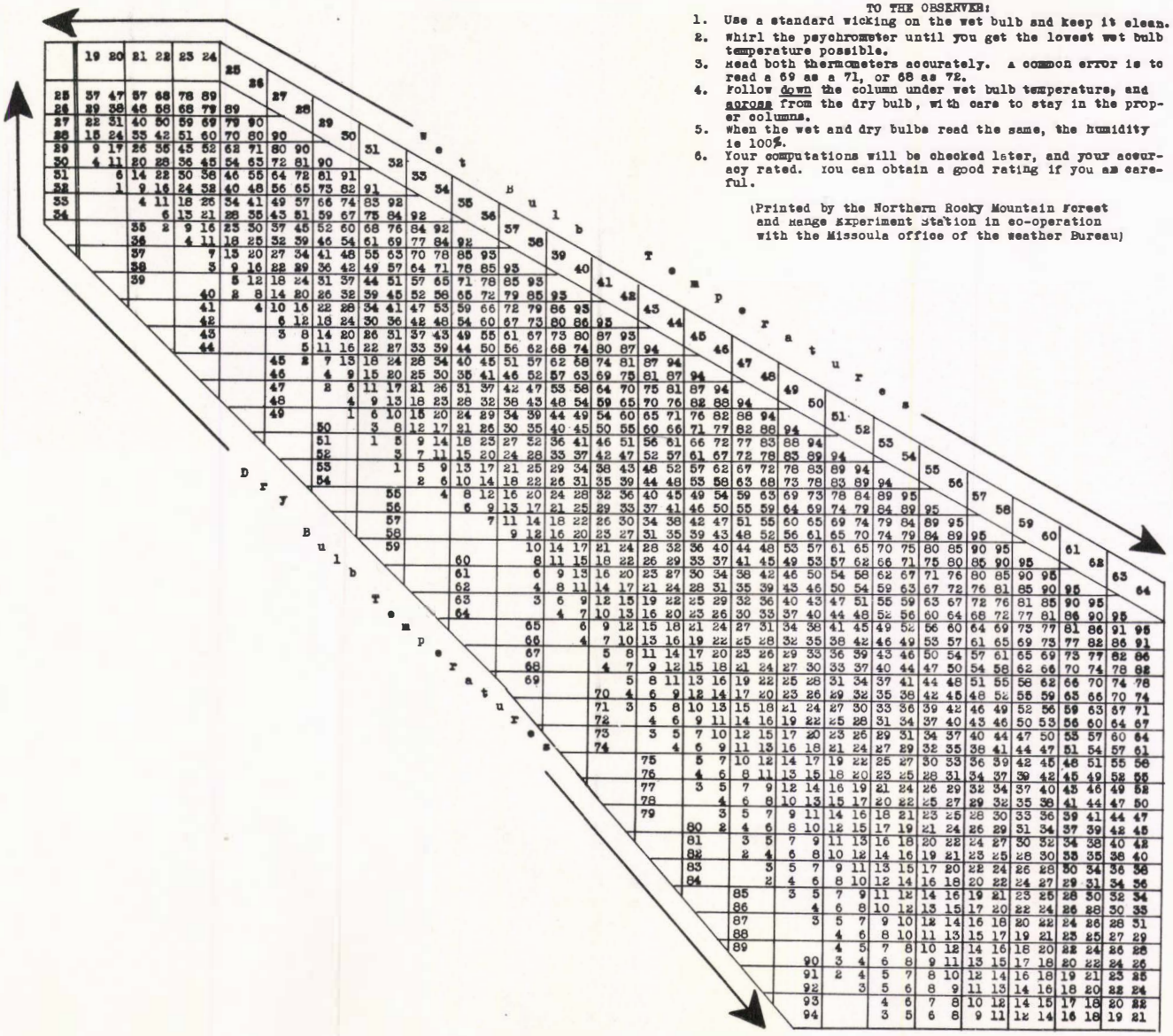


RELATIVE HUMIDITY
Pressure 25"
Elevation 5800 to 6000 Feet

TO THE OBSERVER

1. Use a standard cotton wicking on the wet bulb and keep it clean. Use clean water to wet the wet bulb before whirling.
2. Always stand in the shade when measuring humidity. If it is raining stand under a porch roof or where rain drops cannot strike the thermometer bulbs.
3. Whirl the psychrometer until you get the lowest wet bulb temperature possible. Whirl the instrument at a rate of about 800 r.p.m.
4. Read both thermometers accurately. A common error is to read a 69 as a 71, or 68 as 72. Another is to read 55 as 60 or 55.
5. On this table follow down the column under wet bulb temperature, and across from the dry bulb, with care to stay in the proper columns. The figure at the intersection is the relative humidity for these temperatures.
6. When both bulbs read the same, after proper wetting and whirling, the relative humidity is 100%. These have been omitted from this table to save space.
7. Your computations will be checked later, and your accuracy rated. You can obtain a good rating if you are careful.

This table prepared by Division of Fire Research,
Northern Rocky Mountain Forest & Range Experiment Station.



RELATIVE HUMIDITY
Pressure 23"
Elevation 6000 feet or more

TO THE OBSERVER:

1. Use a standard wicking on the wet bulb and keep it clean.
2. Whirl the psychrometer until you get the lowest wet bulb temperature possible.
3. Read both thermometers accurately. A common error is to read a 69 as a 71, or 68 as 72.
4. Follow down the column under wet bulb temperature, and across from the dry bulb, with care to stay in the proper columns.
5. When the wet and dry bulbs read the same, the humidity is 100%.
6. Your computations will be checked later, and your accuracy rated. You can obtain a good rating if you are careful.

(Printed by the Northern Rocky Mountain Forest and Range Experiment Station in co-operation with the Missoula office of the Weather Bureau)

FIRE-DANGER STATION
INSPECTION--SELF-TRAINING GUIDE

Forest_____ District_____ FD Sta._____

Observer_____ Inspector_____ Date_____

S = Satisfactory; U = Unsatisfactory

	General	
1	Grass, etc. 4" or less	
2	Brush, etc. cut 20' around enclosure.	
3	Fence or gate in good repair.	
4	Anemometer exposure satisfactory.	
5	Pole solid, sound	
6	Pole steps in place	
7	Pole lightning protection adequate.	
8	Buzzer lightning protection adequate.	
9	Arrangement good as to exposure, etc.	
	Instrument Shelter	
1	Solid	
2	Floor level	
3	Clean inside.	
4	White outside	
5	Adequate.	
6	Opening away from wind and sun.	
	Scales	
1	Clean, dust-free.	
2	Balances at zero.	
3	Balances with 100-gram check weight	
4	Bearings clean.	
5	Weights clean	
6	Appalachian-type vertical, solid.	
7	Sticks centered across center of pan.	
8	Scale arm moves freely.	
9	Weights set in notches.	
10	Main bearing cover tapped before reading.	
11	Scale read and recorded properly.	
12	Weights set out of notches after weighing, and away from zero	
	Anemometer	
1	Vertical	
2	Solid	
3	Cups tight, undamaged	
4	Rotates freely.	
5	Clean	
6	Oiled monthly	
7	Buzzer or flasher o.k.	
8	3 readings per afternoon.	
9	2 minutes per reading	
10	Readings averaged properly.	

	Scale Shelter	
1	Solid	
2	Floor level	
3	Clean inside.	
4	Leakproof	
5	Opening away from wind.	
6	Adequate.	
	Fuel Sticks	
1	Screen: taut, no holes	
2	correct size	
3	2 layers, 14-mesh.	
4	13" high	
5	Duff bed: ½-1" thick	
6	no humus underneath.	
7	free of grass, weeds	
8	conifer needles used	
9	clean.	
10	undamaged.	
11	hook end north	
12	nail side down	
13	rack 10" high.	
14	rack of galvanized wire.	
15	handled properly	
16	free water shaken off before weighing	
	Psychrometer	
1	Tubes clean	
2	Wicking clean	
3	Wicking 1" beyond bulb.	
4	Water clean	
5	Fan-type solid.	
6	Fan-type oiled.	
7	Chain, etc. not worn.	
8	Wicking wetted only at start.	
9	Slung or cranked till wet bulb will go no lower	
10	Slung in shade, out of rain	
11	Wet bulb read first	
12	Hands kept off tubes.	
13	Table read properly	

Rain Gage

1 Funnel top correct height. . . . . .
2 Support solid. . . . . .
3 Funnel top level . . . . . .
4 Funnel top undamaged, circular . . . . .
5 Measuring tube watertight. . . . . .
6 Overflow can watertight. . . . . .
7 Clean inside . . . . . .
8 Measuring stick clean, legible . . . . .
9 Measuring stick used properly. . . . . .
10 Amount read and recorded properly (nearest .01"). . . . . .

Maximum-Minimum Thermometer

1 Shaded properly. . . . . .
2 Columns not separated. . . . . .
3 "Spinner" oiled. . . . . .
4 Minimum read first . . . . . .
5 Maximum read in vertical position. . . .
6 Thermometers read with eye at same level as top of columns . . . . . .
7 Minimum set last . . . . . .

Hygrothermograph

1 Dust-free . . . . . .
2 Pens inking properly. . . . . .
3 Low humidity reading after leveling off in afternoon coincides with current humidity by psychrometer . . . . .
4 Maximum humidity at night between 95 and 100 percent . . . . .
5 Clock speed correct . . . . . .

Miscellaneous

1 Measurements taken at proper time . . . . . .
2 BI computed properly. . . . . .
3 BI predicted daily. . . . . .
4 Form 120-INT instructions followed . . . . . .
5 Form 1009-E instructions followed . . . . . .
6 OBSERVER KNOWS WHY HE IS TAKING FIRE-DANGER MEASUREMENTS . . . . . .